Abstracts

XVIII Congress of the International Society of Electrophysiology and Kinesiology
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NOTE TO READER: The full proceedings of the XVII Congress of the International Society of Electrophysiology and Kinesiology (ISEK), hosted in Aalborg, Denmark from 16 June 2010 to 19 June 2010, were constructed as a set of web pages delivered on a CD. As such, each abstract is contained in a separate PDF file, each file being hyperlinked from a Table of Contents and also from an Author Index. We have combined those files into three PDF files. One PDF file contains the Table of Contents (without hyperlinks). Another PDF file contains the Author Index (without hyperlinks). The third file contains all of the presented abstract papers, concatenated. Readers are encouraged to peruse the Table of Contents and Author Index files in order to identify abstracts of interest to them. To find the full abstract within the abstract file, readers can search within the abstract file by the identified title or author. Note that some author last names are not unique and many authors contributed multiple papers.

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Summer School

International Society of
Electrophysiology and Kinesiology

Summer School

Neurorehabilitation – Recovery of Motor Function

Organizer: Dejan Popović, Aalborg University, Denmark

Methods for movement assessment

Michael Voigt, Aalborg University, Denmark

Assessment and analysis of human movement requires collection of kinematic and kinetic information in one two and/or three dimensions depending on the kind of movement in question, Eventually, in combination with other kind of physiological information like muscle activity (EMG) or oxygen consumption. For the purpose of movement analysis more or less complicated sensors, sensor systems and data acquisition systems have been developed which and the way these sensor systems are applied depends on the information need. Also, movement analysis has to be performed with proper attention to limitations and sources of error. A presentation of the stat of the art with in movement analysis will be given with relevant examples and advantages and shortcomings will be discussed.

Summer School

Neurorehabilitation – Recovery of Motor Function

Organizer: Dejan Popović, Aalborg University, Denmark

Nociceptive stimulation in neurorehabilitation

Ole Kæseler Andersen, Aalborg University, Denmark

Summary: Painful stimulations can be used for activating spinal polysynaptic reflex pathways and thereby obtain an integrated motor response involving several muscles/joints. The primary application is gait rehabilitation after stroke or spinal cord injuries where electrical stimulation of individual muscles primarily focuses on muscles affecting the knee and ankle joints while hip flexion is problematic. Reflex pathways may also involve joint extension by proper selection of stimulation site and timing in the gait cycle. Normal muscle fiber recruitment is obtained during the reflex response opposite to artificial electrical stimulations of muscles. However, reflex habituation is a major challenge and forward propulsion is difficult to initiate and control despite evidence for activation of spinal stepping circuits by the sensory stimulus.

Summer School

Neurorehabilitation – Recovery of Motor Function

Organizer: Dejan Popović, Aalborg University, Denmark

Suprathreshold stimulation for neurorehabilitation

Thierry Keller, Fatronik Technalia, San Sebastian, Spain

Summary: Stimulation above motor or sensory threshold is currently used in neurorehabilitation mainly for functional training. Nerves and muscles can be activated magnetically and electrically. For eliciting and executing motor functions transcutaneous (surface) electrical stimulation (TES) is the most frequently applied technique in clinical practice despite the huge efforts made to improve implantable technologies and some marginal efforts done in applying magnetic stimulation. Stimulation electrodes play an important role in interfacing the tissue with the stimulation unit. New techniques concentrate on multi-channel approaches and intelligent control for excitation and modulation of neural activity. Nevertheless, the systems need to be properly adapted to specific pathologies and need to take into account remaining neural properties and neuropathological changes that occur after an incidence affecting the motor-sensory system.

The lecture will introduce main changes and effects affecting the functions that currently can be provided by electrical stimulation, provide a brief overview about the used technology and give some insights into new emerging technologies.

Summer School

Neurorehabilitation – Recovery of Motor Function

Organizer: Dejan Popović, Aalborg University, Denmark

Robots for neurorehabilitation

Vittorio Sanguineti, University of Genova, Genova, Italy

Summary: During the last decade, robots have been used to promote the recovery of motor functions of stroke survivors. Robot therapy seems promising, but it is unclear which robot designs and which exercises are more effective. Similarly, it is unclear whether other pathologies may benefit from this technique. The lecture will review the available technologies and the design principles for rehabilitation robots. As regards exercises, I will argue that they should exploit the adaptive nature of the nervous system, promote active movement performance and include problem-solving aspects.

Another important aspect is the type and amount of the assistance provided by the robot. I will suggest that assistance should be kept to a minimum, should be tailored to the different degrees of impairment, and should adapt to changing performance. The notions of minimal assistance and adaptivity might also suggest how to extend robot therapy to other pathologies.

Summer School

Neurorehabilitation – Recovery of Motor Function

Organizer: Dejan Popović, Aalborg University, Denmark

Implantable devices for Neuromodulation

Ljubomir Manola, Boston Scientific Neuromodulation Europe, Brussels, Belgium

Summary: Neuromodulation is a therapy that modulates back to the normal state the output of a neural network which exhibits an abnormal behavior due to an impairment/abnormality[1]. This is accomplished by supplying a neuromodulatory input to the neural network by an (implantable) neuromodulatory system. In electro-neuromodulation, the neuromodulatory input is achieved by electrical neurostimulation delivered by electrodes connected to an (implantable) pulse generator (neurostimulator)[2]. Various parts of nervous system are targeted depending on desired effects and disorder to be treated – deep brain nuclei, parts of brain cortex, spinal cord, peripheral nerve or their endings[3]. To date, chronic neuropathic pain, angina, central motor disorders, epilepsy, urinary and psychiatric disorders are among well-established clinical indications[1].

Increasing our understanding of the nervous system and its disorders as well as effects of neurostimulation, better patient selection, building clinical evidence and advancements of technology are all helping to further expand indications and number of patients treated, with enormous potential for the future. Given the size of the market and potential for its expansion, it is not surprising that the number of interested commercial parties is increasing. This is necessarily accompanied by increasingly stringent regulatory requirements for commercialization of the implantable devices.

The presentation will provide overview of the electro-neuromodulatory therapies and systems as well as give an industry perspective.

References

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Summer School

Neurorehabilitation – Recovery of Motor Function

Organizer: Dejan Popović, Aalborg University, Denmark

Techniques to assess cortical and spinal cord plasticity

Natalie Mrachacz-Kersting, Aalborg University, Denmark

Summary: The human sensory and motor cortices as well as the spinal cord have the capacity to change as a result of alterations in sensory input, motor practice, or damage. Such changes are often likened with those in animal preparations termed long-term potentiation (LTP) and long-term depression (LTD). The challenge in human studies is to assess such changes using non-invasive techniques such as assessment of H-reflex, stretch reflex, motor evoked potentials etc. The limitations of these techniques for the quantification of plasticity in the intact human at both the spinal and cortical level will be described and discussed.

Summer School

Neurorehabilitation – Recovery of Motor Function

Organizer: Dejan Popović, Aalborg University, Denmark

Diseases and injuries of the CNS leading to sensory-motor impairment
Mario Manto, Université Libre de Bruxelles, Belgium

Summary: Neurological disorders such as stroke, Parkinson's disease or trauma are commonly encountered worldwide. They are associated with variable deficits at the sensory-motor level. The burden of neurological disorders has been underestimated by traditional epidemiological studies taking into account only mortality, and not the disabilities. The characterization of the numerous deficits encountered in diseases and injuries of the CNS has greatly improved these last 3 decades, especially with the advent of accurate neuroimaging techniques and the integration of MRI with neurophysiological tools. This lecture will provide an overview of the neurological disorders impairing sensory-motor functions. The main diseases will be reviewed, with a focus on the pathogenesis of the sensori-motor deficits. The functional impacts on cerebral cortex, basal ganglia, cerebellum and spinal cord will be discussed.

Summer School

Neurorehabilitation – Recovery of Motor Function

Organizer: Dejan Popović, Aalborg University, Denmark

Motor learning

Herbert Heuer, IfADo, Germany

Summary: Techniques of rehabilitation are likely to benefit from principles of motor learning. A core problem of motor learning is to achieve mastery of novel relations between motor commands and the resulting movements. In healthy humans this kind of learning has been studied by various means such as modified vision of ones own limb, tools which implement novel kinematic transformations, and introduction of novel force fields. In this lecture the learning problem will be introduced and mechanisms involved in solving it will be described. Emphasis will be placed on situational conditions such as feedback and personal conditions such as age which modulate the functioning of these mechanisms.

Summer School

Neurorehabilitation – Recovery of Motor Function

Organizer: Dejan Popović, Aalborg University, Denmark

The Specificity of Neuromuscular Adaptations

Roger Enoka, PhD, Professor and Chair, Department of Integrative Physiology, University of Colorado, Boulder, CO, U.S.A.

Summary: Voluntary actions involve a cascade of physiological processes that originate in the cerebral cortex and are manifested as an interaction between muscle torques and the constraints imposed by the surroundings. For at least the last century, physiologists have appreciated that all elements of the motor system are plastic. In the last few decades, however, it has become apparent that the adaptations evoked in the motor system by physical activity depend on the details of the stimulus. Classic examples of this specificity, which will be discussed in the lecture, include the adjustments that occur during fatiguing contractions and the adaptations that accompany strength training.

Workshops

Keynote Lectures

Oral Sessions

Poster Sessions

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CHARACTERISTICS OF CENTER OF PRESSURE TRAJECTORIES BY NONLINEAR ANALYSIS IN THE ELDERLY PERSONS WITH MILD PARKINSON'S DISEASE

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AIM: The purpose of this study was to examine the dynamics of center of pressure (COP) trajectories in elderly persons with mild Parkinson's disease (PD) patients by nonlinear analysis.
METHODS: Subjects were 10 elderly persons with mild PD patients (PD group, Hoehn and Yahr stage 2, mean age ± SD = 75±5 years) and 15 age-matched healthy elderly persons (HE group, mean age ± SD = 72 ± 5 years). COP time series data for 30 seconds was recorded from twin gravicorder G-6100 (Anima, Japan) with sampling rate of 200Hz. Subjects were standing with both eyes opened and eyes closed for 30 seconds. PD patients were evaluated on phase after 2 hours of taking anti-parkinsonian drugs. All of PD patients did not present involuntary movement, on-off phenomenon, wearing off phenomenon, and dopa-induced dyskinesia. Root mean square (RMS), COP velocity (V), correlation dimension (D2), and largest Lyapunov exponent ($\lambda 1$) were calculated from the time series data of COP in anterior-posterior direction. D2 and $\lambda 1$ were calculated by Grassberger-Procaccia algorithm and Sano-Sawada algorithm, respectively. Comparisons between and within the two groups were performed by unpaired t-test and paired t-test, respectively.
RESULTS: The $\lambda 1$ and RMS for the PD group at the standing with both eyes opened and eyes closed were significantly greater than those for the HE group ($p<0.01$). The D2 for the PD group at the standing with eyes closed was significantly smaller than that for the HE group ($p<0.01$). The D2 for the HE group at the standing with eyes closed was significantly increased than that for the HE group at the standing with eyes opened ($p<0.01$), but the D2 for the PD group was not significantly increased at the standing with eyes closed.
CONCLUSION: The COP trajectories for PD group at the standing with both eyes opened and closed were characterized by marked swaying dynamics with high instability. No change of D2 for the PD group at the standing with eye closed assumed to be due to the decrease of processing to enrich information so as to facilitate the control of standing posture. Nonlinear analysis could detect the dynamic characteristics in the COP trajectory even for the mild PD patients, demonstrating the usefulness of this technique for assessing the postural control function in the mild stage PD patients.

Table 1: Parameters of Center of pressure in two postural conditions (mean ±SD)

	Standing with Eyes Opened		Standing with Eyes Closed	
Group	**Elderly**	**Parkinson**	**Elderly**	**Parkinson**
$\lambda 1$	0.17 ± 0.37	0.42 ± 0.63*	0.16 ± 0.24	0.33 ± 0.41*
D2	3.54 ± 0.75	3.34 ± 0.57	4.14 ± 0.80	3.45 ± 0.74*
RMS(cm)	0.45 ± 0.25	0.57 ± 0.23*	0.48 ± 0.21	0.62 ± 0.25*
V(cm/s)	1.58 ± 0.54	1.68 ± 0.40	2.24 ± 0.58	2.05 ± 0.49

*: $p<0.01$, ć : $p<0.01$, *: comparison between the two groups, ć : comparison within the two groups

PROLONGED TENDON VIBRATION REDUCES H-REFLEXES WITHOUT AFFECTING DYNAMIC PLANTAR FLEXOR ACTIVATION AND STRENGTH

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BACKGROUND: Neural activation is generally lower during maximal voluntary lengthening as compared to shortening and isometric muscle actions, but the mechanisms underlying these differences are unclear. For isometric muscle actions, studies have shown that input from Ia-afferents contributes to neural activation, since reducing Ia-afferent excitation efficacy caused decreased maximal voluntary activation and strength.
AIM: The aim of this study was to investigate whether reducing Ia-afferent excitation efficacy would influence neural activation in dynamic muscle actions, and, if so, whether it would affect shortening and lengthening muscle actions differently.
METHODS: Eight women participated in 3 familiarization sessions and 2 randomly ordered experiments. In one experiment, 30 min vibration was applied to the Achilles tendon to decrease the excitatory efficacy of the Ia-afferents as measured by the H-reflex. In the control experiment, rest substituted the vibration. Root mean square EMG from plantar and dorsiflexor muscles and plantar flexor strength were measured during maximal voluntary plantar flexor shortening and lengthening actions before and after vibration and rest, respectively. Soleus H-reflexes and M-waves were elicited before each set of strength tests.
RESULTS: The vibration caused a decrease in H-reflex amplitude by, on the average, 33 %, but root mean square EMG and plantar flexor strength remained largely unaffected in both action types.
CONCLUSION: The findings suggest that Ia-afferent input may not substantially contribute to maximal voluntary dynamic muscle strength of the plantar flexor muscles, as tested here, and thus, the results do not support the notion that Ia-afferent excitation would contribute more to neural activation in maximal voluntary lengthening than shortening muscle actions.

LOAD SUPERIMPOSITION ON A SINGLE DIGIT ENHANCES RELEASE OF INTERDIGIT COUPLING AND MANUAL TRACKING

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AIM: This report aims to examine the role of load superimposition on the modification of inter-digit independence during manual tracking through interplay among finger tremors.

METHODS: Sixteen healthy adults conducted sinusoidal position tracking with and without an imposing mass on the non-dominant middle finger. Physiological measures included electromyographic activities of the extensor digitorum (ED)/flexor digitorum superficialis (FDS) and physiological tremors of the index, middle, ring, and little fingers.

RESULTS: Similar to the unloaded condition, topological organization of tremor coupling upon loading was largely inversed to the inter-digit distance, but the strength of the coupling was globally reduced due to load addition. Principal component analysis suggested that load addition suppressed 8-12 Hz central rhythm but enhanced 20-40 Hz spectral band of the coherence spectra between primary PC and electromyographic signals of the ED ($Coh\_{PC1-EMG\ ED}$). The observed coherence restructuring to external load was of neuromuscular origins, pertaining functionally to error correction of the tracking maneuver.

CONCLUSION: The implication of this work was that load addition could enhance movement control of the instructed finger, due possibly to a decreased common drive from the central nervous system and enhancement of the proprioceptive feedback from the peripheral nervous system.

CORTICAL AND MUSCULAR SIGNALS IN ACTIVATING AND DEACTIVATING KNEE EXTENSOR MUSCLES

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AIM: To learn cortical and muscular signal characteristics for controlling voluntary activation and deactivation of human skeletal muscles. This information is currently not available.

METHODS: Twelve healthy volunteers (24.2 ± 5.8 years, 9 men) participated in the study. They performed isometric knee extension contractions (45 trials with a 10-s rest between trials) using the right leg at a target level of 20% MVC force. In each trial, subjects held the force at the target for 10s after reaching it and then relaxed the force to the baseline. The rate of force ascending (activation) and descending (deactivation) was ~4% MVC/s. Visual feedback of the exerted force together with the force target was provided. Electroencephalographic (EEG) data were recorded from the scalp using a 128-channel system during all contractions along with the knee extension force and electromyographic (EMG) signals from vastus medialis (VM), vastus lateralis (VL) and rectus femoris (RF) heads of the quadriceps femoris muscle. Cortical signals for activating and deactivating the muscles were quantified by estimating amplitude of the MRCP (from baseline to negative peak) derived by force-triggered averaging of the 45-trial EEG data at times right before the muscle activation and deactivation. Muscle signals were quantified by analyzing root-mean-square (RMS), median frequency and corresponding power of median frequency of the EMG signals of the VM, VL and RF.

RESULTS: No significant difference in the cortical potential for activating and deactivating the knee extensor muscle was observed. The EMG results showed lower RMS amplitude ($P<0.05$) for the VM and VL during deactivation (VM: 396±168 µV, VL: 506±129 µV) compared with the values of activation (VM: 489±233 µV, VL: 560±145µV). EMG median frequency for the VM and RF were lower ($P<0.05$) during deactivation (VM: 45.2±3.5 Hz, RF: 50.2±9.1 Hz) than during activation (VM: 57.1±9.1 Hz, RF: 53.6±12.8 Hz). The power of median frequency, however, was similar between activation and deactivation for the VM, VL and RF.

CONCLUSION: The similarity in the MRCP amplitude between the muscle activation and deactivation suggests comparable signal magnitude for the brain to plan and execute the activation and deactivation tasks. The reductions in EMG RMS, median frequency and its power during the deactivation phase (vs. activation) may reflect differences in motor unit activities between the two tasks. The results may suggest a larger contribution of a decrease in global motor units firing rate (compared with derecruitment of motor units) to the EMG signal changes during the force descending (deactivation) from than ascending (activation) to the 20%-MVC target force. These findings are relevant to sports medicine practice and neuromuscular function rehabilitation.

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MYOELECTRIC MANIFESTATIONS OF MUSCULAR PAIN, MUSCULAR FATIGUE AND RECOVERY IN JAW ELEVATOR MUSCLES

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AIM: The main aims of the study were: 1) to evaluate the possible use of surface electromyography variables (amplitude and spectral) as objective fatigue indexes, 2) to compare the myoelectric manifestations of muscle fatigue in the temporalis and masseter muscles of both sides during isometric sustained contractions at different force levels, and 3) to assess recovery of the two muscles in both sides after a contraction sustained until endurance.
METHODS: The study was performed on the masseter and temporalis anterior muscles of both sides of twenty healthy volunteers and eighteen muscle-related TMD subject according to Research Diagnsotic Criteria for TMD (RDC/TMD). An intraoral compressive-force sensor was used to measure the voluntary contraction forces in the intercuspal position and to provide a visual feedback on sub-maximal forces to the subject. EMG signals were recorded during different force level (20%, 40%, 60%, 80% of maximum voluntary clenching), during an endurance test and then during the recovery phase.
RESULTS: Results showed that 1) MNF slope can be used as an index of muscle fatigue, differentiating between fatigue development at the different force levels, 2) ARV does not present any typical trend with fatigue, 3) the temporalis anterior and masseter muscles present the same myoelectric manifestations of fatigue at the different contraction levels, 4) The MNF initial value of the masseter muscle depends on the contraction level ($F=17.6$, $p<0.0001$) and on the interaction between group, contraction level and side ($F=4.2$, $p<0.01$). The initial value of MNF decreases with the contraction level. For all the contraction levels and for both sides, TMD subjects showed a decreased initial value of MNF with respect to the healthy subjects ($p<0.05$), 5) during a high force (80% MVC) sustained contraction, pain is induced in the masseter region and this prevents maintenance of the force, 5) the amplitude and frequency parameters recover very fast (2 min) in both muscles.
CONCLUSION: The initial value of MNF can be used as a diagnostic indicator to differentiate TMD-muscle related patients from healthy subjects.

MUSCLE ACTIVITY IN WORK AND LEISURE AND THE RELATION TO MUSCULOSKELETAL PAIN

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AIM: To present knowledge gained from the application of long-term field recordings on the relation between vocational muscle activity and musculoskeletal pain in shoulder/neck and low back. Special attention is given to occupational groups with low to moderate physical activity in work and leisure.
METHODS: A total of 124 female subjects participated, representing five occupational groups: secretaries, bank workers, health care workers, retail workers, and computer workers. Daytime muscle activity from the upper trapezius, upper extremities (deltoideus, biceps, and hand flexors), and low back muscles (multifidus, longissimus, and iliocostalis) was quantified by surface electromyograhic (sEMG) recordings. sEMG activity was normalized as percentage of root-mean-square detected muscle activity at maximal voluntary contraction (EMG_{max}). Work posture (upper arms, pelvis, upper trunk, and sitting vs. upright) was recorded by inclinometers in a sub-sample of workers. Electrocardigraphy (ECG) was recorded in parallel to sEMG recordings in all subjects. Hourly subjective reports of shoulder and neck pain (SNP), low back pain, perceived stress, and perceived tension were related to long-term physiological recordings (sEMG and ECG) and work posture. Associations between subjective reports and physiological responses were investigated by a cross-sectional study design and within-subjects comparisons.
RESULTS: Daytime muscle activity patterns of trapezius and low back muscles were characterized by large inter-individual variation contrasted by high intra-individual consistency in repeated recordings. Work posture had some influence on muscle activity; workers with predominantly seated work posture tended to have lower muscle activity than workers with predominantly standing and ambulating work posture. Perceived stress, perceived tension, and SNP increased during working hours and declined during leisure across all work groups. Relative risk of SNP were twofold among workers with median trapezius activity exceeding 4% EMG_{max} during working hours; however, SNP were also prevalent among workers with low trapezius activity (i.e., median activity $<2\%$ EMG_{max}). Vocational trapezius activity was not related to perceived stress and tension, neither for workers with predominantly seated posture nor standing and ambulating posture.
CONCLUSION: The large inter-individual variation in daytime muscle activity patterns, contrasted by intra-individual consistency in repeated recordings, indicate idiosyncratic activity patterns of trapezius and low back muscles (i.e., individualized motor habits). Workers with predominantly standing and ambulating work posture had higher trapezius activity and higher risk of SNP than workers with predominantly seated work posture; however, SNP was also prevalent among workers with low vocational trapezius activity. The latter may indicate that SNP can develop independently of upper trapezius muscle activity. The lack of association between stress, tension, and vocational trapezius activity does not support the hypothesis of stress-induced low-threshold motor unit activity as causal factor in SNP development.

EMG CHANGE BY WEARING AN ANKLE-FOOT ORTHOSIS WITH OIL DAMPER IN ADULT AFTER STROKE

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AIM: An ankle-foot orthosis (AFO) with oil damper (Gait Solution Design: GSD) was developed to improve a gait performance by plantar-flexion resistances torque to assisting the heel rocker function of hemiplegic gait. The purpose of this study was to determine a change of muscle activation by wearing the GSD during gait in individuals after stroke.
METHODS: Electromyography (EMG) was measured during gait at self-selected speed with wearing a GSD, an AFO with a planterflexion stop (AFO-SP), or an ordinary shoe on affected side in thirteen stroke survivors. To compare with the stroke group, thirteen age-matched healthy adults also walked under same conditions. EMG signal were obtained from Tibialis anterior (TA), Gastrocunemius (GAS), Soleus (SOL) during stance phase. An motion of ankle joint under the GSD or AFO-SP condition and Plantar-flexion resistances torque (PFRT) that occurred by oil damper under the GSD condition were measured by using potentiometer and load cell, simultaneously.
RESULTS: GAS and SOL EMG peak times in stroke group during gait cycle were earlier than those in control group, when they worn the AFO-SP or shoe on affected side. However, a GAS EMG peak time with wearing GSD was later than the other conditions; there was no difference of the peak time compared it in control group (Table.1). Simultaneously, mean GAS amplitude at loading response phase under the GSD condition showed a significant decrease compared it under the AFO-SP condition in stroke group. The peak PFRT was no difference between groups at loading response phase. However, it at pre-swing in control group was significantly higher than in stroke group and significantly related with gait speed.
CONCLUSION: The contribution of the GSD was to assist the heel rocker function due to the PFRT. The GSD may lead to a more normal muscle activity pattern at loading response phase, although the problem that the ankle plantarflexion torque at pre-swing is low in stroke group still remains.

Table 1: EMG peak time in three conditions.

	n	Shoe	AFO-SP	GSD	Difference among conditions p
EMG peak times					
Stroke group					
First peak of TA (% Gait cycle)	12	5.5 (6.4)	3.7 (5.4)	4.0 (1.6) *	0.440
Second peak of TA (% Gait cycle)	12	59.7(8.5)	49.0(9.8)*	61.8 (6.0)	0.004
GAS (% Gait cycle)	12	15.4 (17.0) **	14.8 (15.0) ***	32.3 (20.6)	0.010
SOL (% Gait cycle)	12	11.9 (15.0)***	11.1 (14.5)***	25.6 (17.9)	0.057
Control group					
First peak of TA (% Gait cycle)	12	1.1 (1.4)	1.5 (1.4)	0.6 (1.2)	0.099
Second peak of TA (% Gait cycle)	12	62.7 (8.5)	52.9 (5.0)	61.6(5.4)	<0.001
GAS (% Gait cycle)	11	40.7(2.7)	40.8(2.8)	40.0 (2.7)	0.905
SOL (% Gait cycle	12	39.3(4.7)	40.1(2.6)	39.8 (3.3)	0.934

Values are mean (SD). Significant difference between groups ***p<0.001, **p<0.01, p<0.05

A MECHANISM OF CROSS EDUCATION

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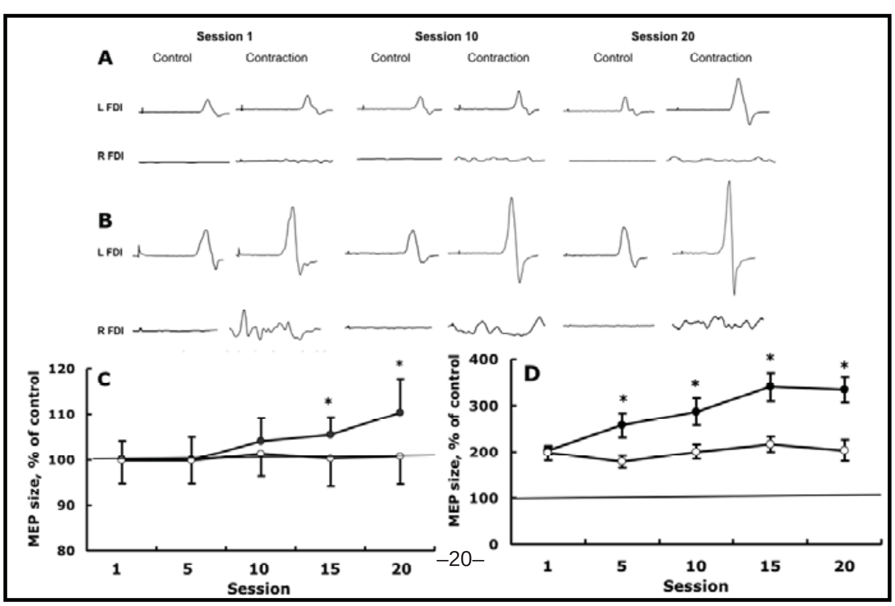
AIM: To determine if unilateral exercise modifies the capacity and sensitivity of the ipsilateral motor cortex (M1), contributing to cross education.
METHODS: Healthy volunteers (n = 12) performed 5 bouts of 10 repetitions of right index finger abduction (FDI) at an intensity of 80% MVC in each of the 20 the sessions in an effort to produce cross education, i.e., increase in voluntary force of the contralateral, left FDI. Single pulse transcranial magnetic stimulation (TMS) was delivered to the right M1, 5 times under each of the following conditions in a random order: 1) at rest (control) at 120% and 160% of resting motor threshold (rMT), 2) TMS at 120% rMT combined with 20% MVC (a measure of M1 sensitivity), and 3) TMS at 160% combined with 80% MVC (a measure M1 capacity). These measurements were done at sessions 1,10, and 20 in the exercise and a non-exercising control group (n = 12).
RESULTS: Training increased MVC 49.9% (SD ±6.3%) in the trained, right FDI and produced 21.8 (±2.3%) cross education in the untrained, left, FDI. No changes occurred in MVC in the control group or in the abductor digiti minimi control muscle. The figure shows a representative example in one subject for changes in the facilitation of motor evoked potentials (MEPs) produced by TMS and muscle contraction. MEPs produced by TMS at 120% rMT in the left FDI at rest (control) and combined with contraction of the right FDI at 20% MVC (panel A) and by TMS at 160% rMT and 80% MVC (panel B). Note the facilitation of MEPs in panel B compared with panel A at rest and due to the stronger contraction and TMS. Note also how the facilitation of ipsilateral MEPs becomes increasingly larger across sessions. Panel C (TMS at 120% rMT+20% MVC) and D (TMS at 160% rMT+80% MVC) show the group data for M1 sensitivity and capacity in the trained (filled symbols) and control group. * $p < 0.05$ between groups, relative to session 1.
CONCLUSION: One mechanism of cross education is that after exercise training with unilateral contractions the "non-involved" M1 becomes highly excitable, increasing its sensitivity and capacity to TMS an contraction. It is unknown if this increased excitability is due to a reduction in interhemispheric inhibition.
ACKNOWLEDGEMENT: NIH NS049783, NIH R01AG02416, East Carolina University's Research Development Grant Program



DYNAMIC ANALYSIS OF ARTIFICIALLY INDUCE STUMBLING GAIT

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AIM: Fall accident and fracture are the important causes of bedridden, which percentage of all the causes is 12 percents. There exist many kinds of cases to occur the fall accident. There are a few studies solved the mechanism of the fall accident. Research of stumble gait in several cases of having fall is studied here.
METHODS: Seven healthy male students participate as subjects in this study. The subjects attended a familiarization session before the experiment. As for the stumble gait, the subjects walk with leg cuff belt at bilateral sides of their distal of legs. Experimenter pulled a string with a leg cuff for the back, and the stumbling gait is recreated by pulling artificially a strap at the back without knowing at right side or left side. The displacement between comfortable gait and the stumbling gait are compared in stance phase of walking cycle.
VICON system is used for analysis of three dimensional movements. Disposable electrodes were attached on right side of m. biceps femoris, m. rectus femoris, m. lateral gastrocnemius and m. anterior tibial. Surface EMG signals of these muscles are recorded during walking at stance phase in walking cycle. EMG sampling frequency was 1KHz.The right side, which is a side of none a fall, are measured in order to evaluate the joint-moment. In the analysis, rectified EMG as RFEMG is evaluated. The statistics for the data of REEMG and joint-moment is carried out with use of Wilcoxon signed-ranks test.
RESULTS: Figure 1 shows a data of RFEMG in one person. The maximum RFEMG of right m. rectus femoris shows toe off of right leg in stance phase. The result denotes that force occurred by the muscle was not work at the maximum distance of COG (center of gravity) from COP (center of pressure). It is also found that the maximum knee joint-moment of flexion at a stumble gait increases at as compared with the value at comfortable gait by significant level of 5%. The tendency is recognized that RFEMG of right side of m. rectus femoris increases in the stumble gait in stance phase of walking cycle.
CONCLUSION: It is found that m. right rectus femoris during the stumbling gait plays important roll in the fall accident.

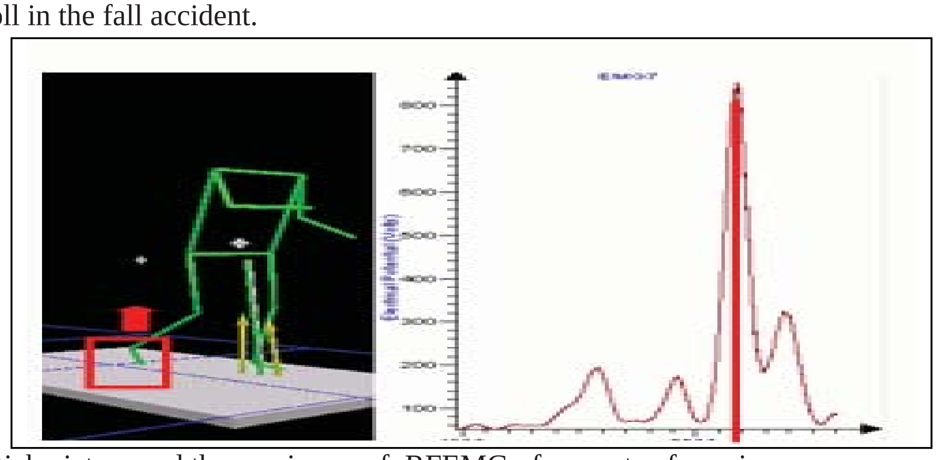

Figure 1: Stick picture and the maximum of RFEMG of m. rectus femoris.

ELECTROMYOGRAPHIC EVALUATION OF THE PERFORMANCE OF CERVICAL FLEXOR MUSCLES IN PATIENTS WITH TEMPOROMANDIBULAR DISORDERS WHILE EXECUTING THE CRANIOCERVICAL FLEXION TEST (CCFT)

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AIM: To determine whether patients with myogenous temporomandibular disorders (TMD) and mixed TMD had altered performance on the superficial cervical muscles expressed in a higher electromyographic activity when executing the craniocervical flexion test compared to healthy control subjects.
METHODS: 150 subjects participated in this study. 47 subjects were healthy, 54 subjects had myogenous TMD and 49 subjects had mixed TMD. All subjects underwent a clinical examination by a physical therapist to determine inclusion for this study. Electrodes were located on the sternal head of sternocleidomastoid (SCM) and in the anterior scalene (SA) as described in the protocol used by Falla et al.[1,2]All subjects performed the craniocervical flexion test (CCFT). The CCFT requires the patient to perform the craniocervical flexion movement in five progressive stages. Subjects were trained through five incremental levels with the aid of visual feedback device. Subjects had to maintain the pressure steady on each target for 10 seconds. The five levels were randomized in order. The subjects repeated this procedure 2 times with a rest period of 1 minute between repetitions to avoid fatigue. Data acquisition was sampled at 1024 Hz, amplified to 10 000 (kilogain) and filtered 20-450 Hz for the analyzed muscles. To obtain a measure of EMG amplitude from SCM and SA, maximum root mean square (RMS) was calculated for 3 seconds for each muscle using IGOR Pro 5.1 and was expressed as a percentage of the EMG activity obtained for each muscle during the MVC. A three –way mixed design ANOVA with repeated measures test was used to evaluate the differences in EMG activity for selected muscles while performing the CCFT under five incremental levels. Clinical importance was assessed using the distribution-based method.[3] The effect size (ES) values were calculated to determine clinical importance of the differences in the electromyographic measurements across different levels of pressure and groups.[4] SPSS 15.0 was used to perform the statistical analysis. The level of significance was set at $\alpha = 0.05$.
RESULTS: A large variability of the normalized EMG activity across conditions and groups was observed. There were marginally no statistically significant differences ($p=0.07$) in electromyographic activity in the SCM or the SA muscles in patients with mixed and myogneous TMD when compared to healthy subjects when performing the CCFT. However, subjects with TMD had a strong tendency (moderate effect sizes) to have increased EMG activity of the cervical superficial muscles when compared to healthy subjects.
CONCLUSION: Moderate and clinically important effect sizes of comparisons between myogenous TMD and mixed TMD, when compared with healthy subjects while performing the CCFT were found. This could indicate a different strategy to activate cervical muscles to stabilize the craniocervical system when compared with pain free subjects. These findings should be taken into consideration when treating patients with TMD. Exercise programs addressing these abnormal motor patterns could be of value when treating these subjects. Future research should test the effectiveness of this type of program in subjects with TMD.
ACKNOWLEDGEMENT**:** Susan Armijo-Olivo is supported by the Canadian Institutes of Health Research, Alberta Provincial CIHR Training Program in Bone and Joint Health, and Physiotherapy Foundation of Canada. This Project was funded by the Physiotherapy Foundation of Canada (PFC) through an Alberta Research Award and by the University of Alberta.

RELIABILITY OF THE NOCICEPTIVE WITHDRAWAL REFLEX THRESHOLDS TO SINGLE AND REPEATED STIMULATION IN CHRONIC LOW BACK PAIN PATIENTS

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AIM: to establish the reliability of the nociceptive withdrawal reflex (NWR) thresholds to single and repeated stimulation in a population of chronic pain patients.
METHODS: Pain and withdrawal reflex thresholds to single and repeated electrical stimulation were assessed in 14 patients suffering from chronic low back pain, in three sessions, consecutive sessions being separated by 7 ± 2 days (mean ± SD). Electrical stimulation was performed through surface electrodes at the innervation area of the sural nerve. Single stimulation consisted of a train of 5 constant-current pulses (1 ms pulse width, delivered at 200 Hz). For repeated stimulation, the same stimulus was applied 5 times at 2 Hz. Electromyographic (EMG) reflex responses to electrical stimulation were recorded from biceps femoris and rectus femoris muscles, using surface Ag/AgCl electrodes. Between-session reliability was assessed using intraclass correlation coefficient (ICC), standard error of measurement as coefficient of variation (CV_{SEM}) and Bland-Altman agreement analysis.
RESULTS: Table I summarizes preliminary reliability results, as the study is still running.
CONCLUSION: The different approaches for reliability analysis applied to NWR thresholds in a chronic pain population result in values that are acceptable for use after a single session. For instance, the ICC is generally higher than 0.75 (indicative of good reliability) for the cases analyzed, whenever the two sessions compared are within a week's time in average. However, the reliability decreases as the session are farther apart in time, possibly due to gradual adaptation to electrical stimulation. Nevertheless, additional measurements are needed to increase the power of the study.

Table 1: ICC, CV_{SEM} and Bland-Altman agreement for NWR thresholds (* $p<0.05$; ** $p<0.01$; *** $p<0.001$ in F test for ICC with hypothesized value of 0.5).

	Single stimulation					
Measure	**Reflex threshold**			**Pain threshold**		
Session	**1 vs. 2**	**2 vs. 3**	**1 vs. 3**	**1 vs. 2**	**2 vs. 3**	**1 vs. 3**
ICC	0.79^{*}	0.83^{*}	0.65	0.89^{**}	0.92^{***}	0.78^{*}
CV_{SEM}	19.9%	17.8%	26.8%	13.6%	12.3%	19.3%
B-A agreement	92.8%	92.8%	92.8%	92.8%	92.8%	92.8%
	Temporal summation					
Measure	**Reflex threshold**			**Pain threshold**		
Session	**1 vs. 2**	**2 vs. 3**	**1 vs. 3**	**1 vs. 2**	**2 vs. 3**	**1 vs. 3**
ICC	0.67	0.76	0.39	0.78^{*}	0.83^{*}	0.61
CV_{SEM}	19.1%	17.8%	30.8%	15.0%	15.5%	23.8%
B-A agreement	100%	100%	92.8%	92.8%	100%	100%

EMG SPECTRAL ANALYSIS OF INCREMENTAL EXERCISE IN CYCLISTS USING FOURIER AND WAVELET TRANSFORMS – A COMPARATIVE STUDY

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AIM: To compare the electromyographic indices of fatigue obtained by the Fast Fourier Transform (FFT) and Wavelet Transform (WT) in trained individuals during cycle exercise.
METHODS: Twelve cyclists (28.0 ± 7.0 years, 70.3 ± 13.0 kg, 176.2 ± 8.5 cm) performed a maximal incremental test (IT) in a cyclosimulator to determine the peak power (Wmax) and electromyographic activity (EMG). Before the start of the IT, each subject had the bipolar EMG electrodes placed over the vastus lateralis muscle (VL). The electrode was positioned on the muscle following the standardization proposed by SENIAM. Mean values of median frequency (MF) were used for the determination of the normalized fatigue index (slope of Median Frequency-NMF_{slp}) and of the MF variance (V_R) with the FFT and WT. The analyzed parameters were obtained for each time period corresponding to 0, 25, 50, 75 and 100% of total duration of the IT. Analysis of variance for repeated measures was used to compare the data regarding the FFT and WT techniques. The limit of statistical significance was set at 5%.
RESULTS: The results of this study are presented in Table 1.

Table 1 Mean values ± standard deviation of median frequency (MF), normalized fatigue index (NMF_{slp}) and MF variance (V_R) obtained by FFT and WT for the vastus lateralis (VL).

	FFT			**WAVELET**		
% TT	**MF**	**NMF_{slp}**	**V_R**	**MF**	**NMF_{slp}**	**V_R**
0%	76.6 ± 9.1	-0.04 ± 0.1	197.3 ± 21.6	74.2 ± 7.7	-0.02 ± 0.1	76.5 ± 6.0*
25%	72.4 ± 7.9	-0.02 ± 0.0	225. 2 ± 26.5	71.9 ± 7.1	-0.01 ± 0.1	82.6 ± 6.0*
50%	70.9 ± 8.6	0.01 ± 0.1	213.8 ± 27.1	71.2 ± 7.6	0.00 ± 0.1	71.6 ± 6.1*
75%	69.2 ± 10.3	-0.03 ± 0.1	243.0 ± 29.5	69.5 ± 8.5	-0.01 ± 0.1	79.2 ± 7.5*
100%	68.3 ± 12.0	0.01 ± 0.1	225.7 ± 22.7	69.1 ± 9.4	0.01 ± 0.1	79.2 ± 5.3*

MF = Median Frequency, NMF_{slp} = normalized fatigue index, V_R = MF variance, % TT = % of total time, *Statistically significant differences were found when comparing the FFT and WT techniques ($P < 0.05$).

CONCLUSION: Although no differences between the methods in calculating the fatigue indices were found, the values obtained using the FFT showed greater data variance when compared to WT. The WT technique seems to be more adequate to dynamic tasks, since it does not require the signal to be quasi-stationary, a limitation imposed by the conventional FFT technique.

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FREEZING *vs* NO FREEZING STEPS IN PARKINSONS DISEASE PATIENTS

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AIM: We present a simple algorithm in the time domain for evaluating episodes of freezing of gait (FOG) in Parkinson's disease (PD) patients by using ground reaction forces.
METHODS: Force sensitive resistor (FSR) sensors attached to a foot were used to study gait. Task included walking through the corridor, doorway pass, U-turn. We studied FOG episodes from 9 PD patients in "on" state. Freezing *vs* no freezing steps were analyzed in the time domain by using Pearson correlation coefficient (Pcc). One "normal" step" was arbitrarily chosen to compute Pcc in correlation to freezing steps.
RESULTS show that Pcc oscillates between ±1 for "normal" locomotion, while during freezing episodes Pcc peaks are reduced to a narrower range. Timings of FOG episodes determined from Pcc analysis overlap with times estimated from video records of walking. Here we propose that Pcc may be used for the detection of FOG.
CONCLUSION: This simple instrument, if added to other ambulatory methods, may provide a tool for better understanding of freezing. Further, we suggest graphical presentation of FOG episodes as the area between Pcc peaks and ±1.
ACKNOWLEDGEMENT: Research supported by the Ministry of Science, Serbia (#145041 and #145057) and the Danish National Research Foundation, Denmark

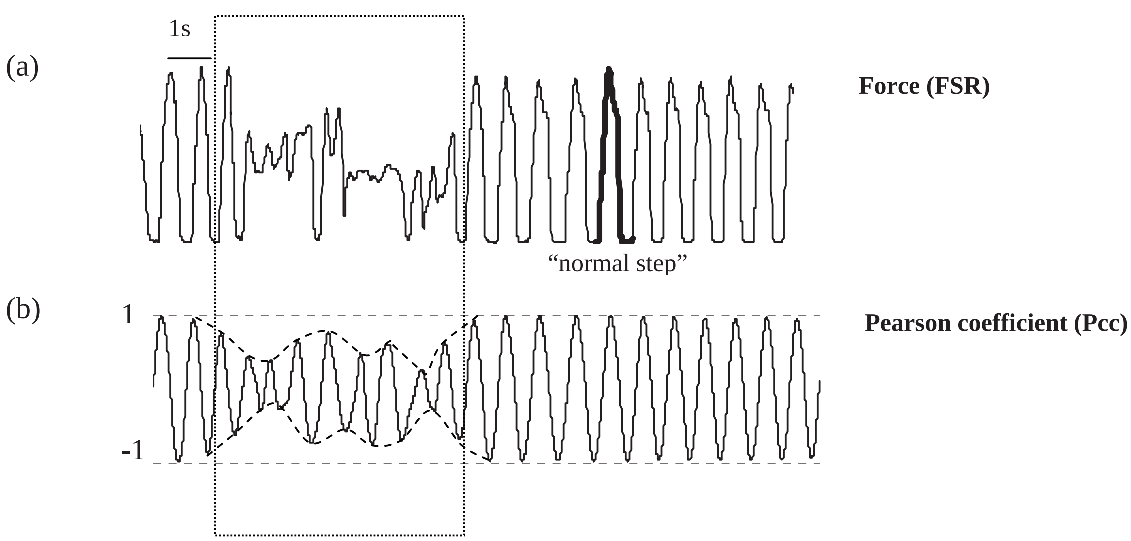

Figure 1: This graph illustrates a typical (a) FSR signal during walking. One "normal" step (tick line) was selected to compute; (b) Pearson's correlation coefficient (Pcc). Pcc extreme values oscillate between -1 and 1. Linear envelope (dashed line) was produced from Pcc peaks with values below ±1. Large window (dotted line) highlights freezing episode.

RATE OF MUSCLE FATIGUE OF THE QUADRICEPS FEMORIS DURING TIME-TO-EXHAUSTION CYCLING EXERCISE

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AIM: The present study compared the fatigue rate among the superficial muscles of the Quadriceps Femoris (QF) during time-to-exhaustion cycling exercise.
METHODS: Peak oxygen consumption (VO_{2peak}) and maximal accumulated oxygen deficit (MAOD) were established by 10 well-trained male cyclists (27.5 ± 4.1 years, 71.0 ± 10.3 kg, 173.4 ± 6.6 cm). Muscle activity (EMG signals) was recorded during the MAOD test. The test was performed with a load corresponding to 110% of VO_{2peak} until volitional exhaustion in a cyclosimulator, always keeping a pedaling cadence of 90 rpm. Before the start of the test, each subject had the bipolar EMG electrodes placed over the QF muscles of the right leg: vastus lateralis (VL), vastus medialis (VM) and rectus femoris (RF). The electrodes were positioned on each muscle following the standardization proposed by SENIAM. The EMG signals of the VL, VM and RF and integrated QF ([VL + VM + RF] / 3) muscles were expressed in median frequency (MF) each 5 sec period and determined using Fourier Analysis - Fast Fourier Transform (FFT). The rate of muscle fatigue was determined through a linear regression procedure, to obtain the slope of the line, from data normalized by the exercise duration (% max) and the initial MF (5 sec). Analysis of variance one-way was used to compare the slopes of muscles. The limit of statistical significance was set at 5%.
RESULTS: The slope of the MF was significantly higher in the RF, followed by the VL and VM (-3.13 ± 0.52 *vs* -2.61 ± 0.62 *vs* -1.81 ±0.56, respectively; $P<0.05$) (Figure 1).

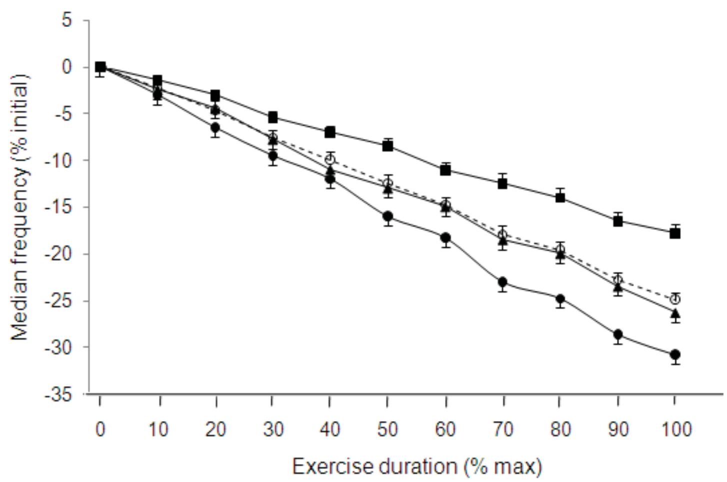

Figure 1: Values (mean ± standard error) of MF of the VL (▲), VM (■), RF (●) and integrated QF (○) muscles.

CONCLUSION: The RF may play an important role limiting performance during time-to-exhaustion cycling exercise (~120 sec).
ACKNOWLEDGEMENT: Supported financially by Fundação Araucária/PR and FAPESP.

EVALUATION OF GAIT CYCLE AND PLANTAR PRESSURE IN DIABETIC PATIENTS WITH AND WITHOUT SENSORY NEUROPATHY: USING THE NEW DEVICE WALKINSENSE®

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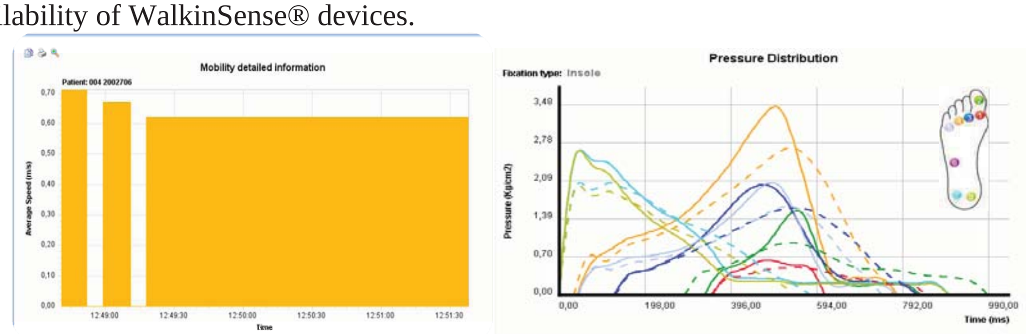
AIM: The purpose of this study was to investigate the relationship of changes in the perception of pressure with the frequency of secondary factors associated with the cadence, the stride duration, length and speed, and plantar pressures in type 2 diabetic patients.
METHODS: We gathered a non-probability convenience sample of 38 patients of both genders, (53% female) with a mean age of 58.9 years, of a podiatry service in a public hospital. For the evaluation of superficial sensory neuropathy, we used the Semmes-Weinstein 10g monofilament. For the evaluation and clinical monitoring of gait activity and plantar pressure trends, we used the new foot pressure and gait evaluation system, WalkinSense®, which allows continuous monitoring and logging of gait cycle kinematics and foot pressures under free walking conditions. Three dynamic tests were performed, two conditioned on a 10 m distance and one taken as free walking for about 2 minutes.
RESULTS: 172 evaluations were performed with the WalkinSense® system. From the total sample, 67% of the patients had diabetes for an average of more than 14 years, 31% of which had sensory neuropathy. It was observed that the duration of stride in the conditioned exams was significantly ($p = 0.000$) lower than that of the free walking examination (Figure 1). It was also observed that diabetic patients with neuropathy also had speed and average stride lengths significantly ($p < 0.05$) lower when compared with patients without sensory neuropathy. We also observed that the average of the maximum pressures in all 8 sensors was lower or equal to 2 kg/cm2.
CONCLUSION: Conditioned examinations of the gait cycle influence its kinematics. Patients with superficial sensory neuropathy have different kinematics of patients without neuropathy. Foot pressure trends during the gait cycle are very much dependant on stride duration, length and speed, and therefore must be evaluated concurrently.

ACKNOWLEDGEMENT: We thank the management and all the staff at the Podiatry service of Hospital of Valongo and its users, and Tomorrow Options – Microelectronics, S.A. for the availability of WalkinSense® devices.



a) b)

Figure 1: a) Difference in average speed (m/s) and b) differences in foot pressure trends on 8 sensors between the conditioned (solid) and free walking (dashed) observations.

STRENGTH AND KINEMATICS EFFECTS OF A FAMILIARIZATION SESSION FOR ISOKINETIC EXERCISE

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AIM: To verify differences between dynamometric and kinematic measurements before and after a familiarization session of isokinetic concentric exercises at different velocities.
METHODS: Eighteen physically active males, (mean ± SD: 22±2 years, 179.1±6.25 cm and 80.12±9.56 kg) were tested in two occasions, a familiarization session (FAM), where the subjects were fully instructed about the maximal isokinetic test procedures, and performed (after few submaximal trials) 5 concentric knee extensor isokinetic contractions (90° to 170°, 180° = full extension) at $60°.s^{-1}$ and $180°.s^{-1}$ in random order. After 5-minutes rest interval, subjects were allowed to perform more 2 sets of 5-maximal isokinetic contractions (the familiarization itself). The second occasion was conducted at least five days later, the (already familiarized) subjects returned to the laboratory to repeat the maximal concentric isokinetic knee extensions at $60°.s^{-1}$ and $180°.s^{-1}$(MAX), again in random order. Knee extensors peak torque (PT), time to achieve the PT ($Time_{PT}$), angle relative to PT (Ang_{PT}) and total work (TW) were the dependent variables. Paired samples Student's t-tests were used to analyze differences between FAM and MAX, with significance level set at $p<0.05$.
RESULTS: There were significant effects ($p<0.05$) of familiarization session on PT and TW for the both movement velocities (Table 1). This means that subjects were able not only to reach a higher maximal value, but higher power output through the entire contraction. The improvements were approximately 10% between sessions, which may be related to motor learning at neural level. However, only at $60°.s^{-1}$ the $Time_{PT}$ was significantly decreased ($p<0.05$) during MAX, indicating that, at this velocity, subjects were able to contract stronger and reach maximal torque earlier (i.e. faster). No significant differences were found for Ang_{PT} between FAM and MAX for the both velocities.
CONCLUSION: A single session of familiarization can improve the PT and TW by 10%, regardless the movement velocity. However, at $180°.s^{-1}$ there is a differential mechanism related to familiarization, since the contraction was stronger, but no faster during MAX.
ACKNOWLEDGEMENT: We would like to thank FAPESP, CNPq and CAPES for financial support.

Table 1: Peak torque (PT), time to achieve the peak torque ($Time_{PT}$), angle of the peak torque (Ang_{PT}) and total work (TW) during knee extensor isokinetic concentric contraction at $60°.s^{-1}$ and $180°.s^{-1}$, performed during the familiarization (FAM) and the maximal session (MAX). * denotes significant difference in relation to FAM ($p<0.05$).

Velocity	**$60°.s^{-1}$**		**$180°.s^{-1}$**	
Session	**FAM**	**MAX**	**FAM**	**MAX**
PT (Nm)	210.4±51.1	232.9±47.7*	160.8±33.3	173.7±33.9*
$Time_{PT}$ (ms)	587.±88.8	535.8±63.3*	235.5±33.8	237.2±55.1
Ang_{PT} (°)	57.±5.5	58.4±3.6	55.6±5.4	55±9.3
TW (J)	263.8±60.3	294.8±54.4*	85.3±23.2	92.5±19.5*

STRUCTURAL, FUNCTIONAL AND PROTEOMIC ANALYSIS OF HUMAN SKELETAL MUSCLE FOLLOWING ELECTRICAL STIMULATION (ES) STRENGTH TRAINING

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AIM: Whereas the impact of ES strength training on skeletal muscle mass and function has been described in detail, no data are available on the plastic muscular adaptations at the level of single muscle fibers and the molecular mechanisms underlying such adaptations. Thus the present study aimed to investigate single fibers functional and structural changes and whole muscle proteome adaptation to bilateral ES of the quadriceps muscle in young subjects.
METHODS: 14 young (18-30 years of age), healthy, male subjects were subjected to 24, 18-min sessions of isometric (bilateral) over a period of 8 weeks with 3 sessions per week. Needles biopsies were taken from the vastus lateralis muscles pre- and post-training. Single fibres were dissected from bioptic samples and chemically skinned. Isometric specific tension (Po/CSA) and maximal shortening velocity (Vo) were estimated at pCa 4.6. MHC composition of the fibre segments and bulk muscles were analysed by SDS-PAGE followed by computerized gel electrophoresis. Change in MHC mRNA expression were quantified by real-time PCR analysis. 2D gel electrophoresis was used to examine the overall protein pattern before and after NMES and spot identification was confirmed by Western Blot.
RESULTS: Maximum voluntary contraction (MVC) and neural activation were found to be significantly higher post-training (+20% and +9% respectively). MHC isoform distribution showed a significant shift from MHC-2X towards MHC-2A and MHC-1, i.e. a fast to slow transition. Real-time PCR analysis of changes in MHC expression showed the same pattern. α-cardiac, embrional and perinatal MyHC isoforms, considered as transitional isoforms, were expressed at the levels of mRNA but not at the level of protein. Significant increase in Po/CSA in type 1 and 2A fibers (range +8-30%) and Vo in type 1 and 2A and hybrid fibers 1-2A and 2A-2X (range +11-40%) were observed. Fluorescently stained proteome maps showing ~600 spots were identified and subdivided in different categories. A significant increased expression of oxidative and antioxidant enzyme expression was observed following ES.
CONCLUSION: ES strength training exerts a profound change in function and structure at the level of single muscle fibers and in protein expression pattern of bulk muscle. These changes highlight a peculiar muscular plastic response to ES strength training in comparison with voluntary training.
ACKNOWLEDGEMENT: This study was supported by PRIN2007 to GD.

EFFECT OF PILATES EXERCISES ON BACK MUSCLE ACTIVITY IN HEALTHY FEMALES

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AIM: To examine the electromyography activity of back muscles during three traditional mat Pilates exercises (swimming, single leg kick and double leg kick).
METHODS: Eleven healthy females volunteers, aged between 18 and 36 years (body mass index=21 kg/m^2, SD=1) took part in this study. EMG signals were recorded with two pairs of surface electrodes placed bilaterally on lumbar extensor muscle (L5). The EMG amplitude in the phases of each exercise was identified by video analysis. The electrical muscular activation was normalized by the percentage of maximal EMG activity obtained from maximal voluntary isometric contraction, and used to compare the activities.
RESULTS: The electrical muscular activity of the lumbar extensors ranged between 15% and 61% across the three Pilates conditions (Figure 1). The swimming exercise increased lumbar extensor activity (29% on average) in comparison to the other two Pilates conditions. Interestingly, the double leg kick condition significantly generated more activity of the lumbar extensors (26% on average) as compared to the single leg kick condition.
CONCLUSION: The Pilates exercises, specially swimming condition, may be a useful way to localize the effects of endurance training at the back muscles. This has implications for rehabilitation of low back pain patients.
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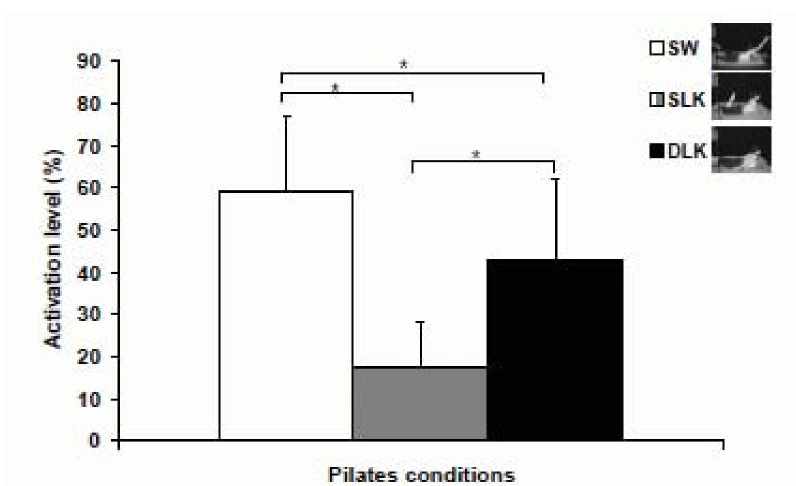

Figure 1: Activation level values pooled across muscles during the three Pilates conditions: swimming (SW); single leg kick (SLK), with prone static back extension and double leg kick (DLK).

A NOVEL AND EFFECTIVE TREATMENT MODALITY FOR MEDICALLY UNEXPLAINED SYMPTOMS

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Medically unexplained symptoms (MUS) confound physicians, and the incidence and prevalence of these conditions is poorly documented. This is not least due to the complex nature of MUS and mimicry of morbidity with conditions that have common clinical assessment and treatment modalities, e.g. migraine headaches which stress headaches commonly are misdiagnosed as. Effective treatment modalities for MUS have been more or less non-existent. In the following we present a modality for the assessment, diagnosis and treatment of MUS that in our experience leads to cure, at least in better than half of these cases measured in terms of allowing the individual *back to work*. These results are at least twice as high as those described hitherto (see below), and yet, our treatment modality is beset with many obstacles, not the least of which is the intransigence of a system that will not and/or can not understand why this modality is so much better than what they are able to offer. The most important obstacle is financing, as this modality requires long term and committed financing to work. The economic implications of not dealing with these issues are described.

INFLUENCE OF CONTRACTION INTENSITY ON ELECTROMYOGRAPHIC ACTIVITY AND PERCEIVED EXERTION DURING ARM ABDUCTION

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AIM: To verify changes in the rating of perceived exertion and electromyographic activity according to the intensity of the task.
METHODS: 24 males (age=22.5 years, SD=2.1; weight=71.8 kg, SD=11.2; height=176,7cm, SD=6.8) who do not present any musculoskeletal disorder were evaluated during isometric scapular plane arm abduction in four different loads (20, 30, 40, 50 % of the maximum voluntary isometric contraction). It was evaluated the electromyographic activity of the muscles: anterior (AD), medium (MD) and posterior (PD) portions of deltoideus, besides trapezius descendents (TD) by bipolar surface electrodes. The subject also reported the rating of perceived exertion (RPE) during the task until exhaustion by 15 point Borg scale.
RESULTS: The slope of RPE is significant difference between loads. However there is no difference in the median frequency slope or the root mean square (RMS) slope with increasing task intensity (Table 1). It was found inflection points of RMS signals however these points were not associated to task intensity increasing (Figure 1).
CONCLUSION: The results of this study suggested a disproportional increase in RPE in relation to electromyographic activity when increasing the task intensity.
ACKNOWLEDGEMENT: To the Master of Science in Physical Education Program of Universidade Estadual de Londrina for partially financial support.

Table 1: Slope values of medium frequency on each load.

	Slope				***P***
	20%	**30%**	**40%**	**50%**	**between loads**
AD	-3.51 (1.33)	-3.16 (1.20)	-3.66 (1.10)	-3.78 (1.61)	>0.05
MD	-3.23 (1.17)	-3.14 (1.27)	-3.57 (0.97)	-3.64 (1.36)	>0.05
PD	-1.85 (1.49)	-1.74 (1.14)	-1.96 (1.14)	-2.14 (1.13)	>0.05
TD	-1.44 (1.19)	-2.37 (1.20)	-2.78 (1.01)	-3.00 (1.14)	>0.05
RPE	0.13 (0.08)	0.13 (0.04)	0.18 (0.07)$^{\$}$	0.22 (0.07)*$^{\$\#}$	<0.05

*P < 0.05 in comparison with 20%; $^{\$}P$ < 0.05 in comparison with 30%; $^{\#}P$ < 0.05 in comparison with 40%.

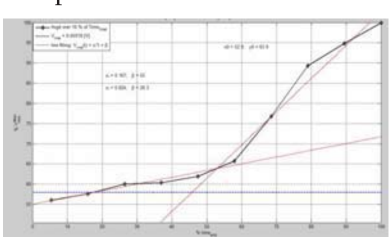

Figure 1: Example of inflexion point on RMS analysis.

DETECTING MERGED MOTOR UNIT POTENTIAL TRAINS USING MUP SHAPE INFORMATION

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AIM: Motor unit potential trains (MUPTs) representing the activity of more than one motor unit (MU), or merged MUPTs, should be excluded from further analysis. Moreover, detecting merged trains during EMG signal decomposition can improve decomposition results. Two methods that evaluate the shapes of the motor unit potentials (MUPs) of a MUPT to see if it represents a single MU (i.e. it is a single MUPT) or if it is a merged MUPT, are presented.
METHODS: Assuming MUPs generated by a single MU are homogeneous in shape (but with possibly different degrees of variability across different MUs) a MUPT can be detected as merged by assessing the homogeneity of its MUPs. Assessing MUP shape homogeneity can be considered as a cluster validation problem and the decision to be made is whether the MUPs of a MUPT represent one or more clusters. Two algorithms based on methods developed for estimating the number of groups in a data set proposed by Beal [1] and, Duda and Hart[2], respectively, have been evaluated for this purpose. Both algorithms include two steps: feature selection and cluster validation. In this work, the MUPs of a given train were represented by the first K principal components, such that 93% of the data variance was accounted for. In the second step, the validity of the given train was assessed using either the Beal or Duda and Hart method.
RESULTS: Forty-three 30s long simulated EMG signals with different levels of intensity (24-93 pps), MUP shape stability (with jitter values from 50-150μs) and IDI variability (CV from 0.10-0.45) were generated [3]. These data allowed the performance relative to signal intensity, number of trains and MUP shape variability to be studied. The simulated signals were decomposed (using DQEMG [4]) and the resulting MUPTs visually assessed to determine single and merged MUPTs. Additional merged trains were generated by merging pairs of single MUPTs randomly selected from each signal. In total 3850 MUPTs (535 single and 3315 merged trains) were tested. The performance of the evaluated methods is summarized in Table 1. For the data set studied, the Duda and Hart method performed consistently better. The overall accuracy of both methods is encouraging.
CONCLUSION: Two methods for characterizing a MUPT are presented. The current results are encouraging and suggest that these methods can facilitate automatic validation of a MUPT and improve EMG signal decomposition results.

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Table 1: The accuracy of the two evaluated methods in correctly characterizing a MUPT.

Method	**Single as Single**	**Merged as Merged**	**Total accuracy**
Beal method	93.2	93.3	93.3
Duda & Hart method	95.5	95.4	95.4

TOWARD AUTOMATIC VALIDATION OF A MOTOR UNIT POTENTIAL TRAIN

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AIM: A novel method is proposed to assess the validity of a motor unit potential train (MUPT) obtained during EMG signal decomposition. It evaluates a MUPT in terms of motor unit potential (MUP) shape homogeneity, motor unit (MU) firing pattern consistency, and the estimated levels of missed and false classification errors (MCE and FCE, respectively).
METHODS: A MUPT can be assumed to be valid if: 1) it represents the firings of a single MU, and 2) its MUPs shapes are homogeneous. To assess a MUPT for these two conditions, a three step pattern recognition based method has been developed. Initially, the MUPT is evaluated using the times of occurrence of its MUPs to determine whether they represent the firings of a single MU or the merged activity of more than one MU, and if it is a single train whether the estimated levels of MCE and FCE in it are acceptable. Ten features of the MUPT firing pattern are extracted and used by two supervised classifiers, the Single/Merged classifier (SMC) and the Error Rate classifier (ERC), and a linear model. The SMC classifier determines whether a train is a single train or not. The ERC classifier determines whether the estimated level of FCE is acceptable or not. The linear model estimates the level of MCE. In the second step, the shapes of the MUPs of a MUPT are assessed. MUPs are represented using the first K principle components, such that 93% of the data variance is accounted for. Validity of a train is assessed using the Duda and Hart method [1] developed for finding the number of groups in a dataset. The third step, combines the temporal and shaped based evaluations using simple AND logic such that a train is considered valid if it satisfies both temporal and shape criteria.
RESULTS: Forty-three 30s long simulated EMG signals with different levels of intensity (24-93 pps), MUP shape stability (with jitter values from 50-150μs) and IDI variability (CV from 0.10-0.45) were generated [2]. The simulated signals were decomposed (using DQEMG[3]) and the resulting MUPTs assessed visually to select valid and invalid MUPTs. Additional invalid trains were generated by merging pairs of valid MUPTs randomly selected from each signal. In total 3850 MUPTs (535 valid and 3315 invalid trains) were tested. Performance for correctly characterizing a MUPT is summarized in Table 1. The overall accuracy in correctly characterizing a MUPT is encouraging. Moreover, invalid MUPTs were detected with greater than 0.99 probability.
CONCLUSION: A pattern recognition based method for validation of a MUPT is presented. It evaluates a MUPT using both firing pattern and MUP shape information. The results obtained using simulated data are encouraging and suggest that using this method can facilitate automatic validation of a MUPT and improve EMG signal decomposition results.

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2. Hamilton-Wright A., Stashuk D.W. (2005), IEEE Trans. on Biomed. Eng., 52(2) 171-183.
3. Stashuk D.W. (1999), Medical Eng. & Physics, 21, 389-404.

Table 1: Average performance for correctly characterizing a MUPT.

Term	**Valid as Valid**	**Invalid as Invalid**	**Total accuracy**
Accuracy (%)	95.5	99.1	98.6

IDENTIFYING FALSE POSITIVE ERRORS IN A MUPT USING BOTH MUP SHAPE AND MU FIRING PATTERN INFORMATION

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AIM: A robust post-processing method to detect motor unit potentials (MUPs) falsely assigned to a motor unit potential train (MUPT) during EMG signal decomposition. This method facilitates more accurate estimation of MUP shape and MU firing pattern statistics.
METHODS: MUPs erroneously assigned to a MUPT generally cause MUP shape and/or IDI inconsistency in the train. To detect these false classification errors (FCEs), a three step pattern recognition method was developed. Initially, erroneous MUPs are identified using shape information. With each MUP in the MUPT represented by 80 time samples (2.56 ms), the 5 samples with the largest consecutive sorted value change (i.e. gap) that are also at least 8 samples (0.26 ms) apart are used to calculate a set of distances d_i, where d_i is the distance between the ith MUP and the MUP template normalized by the RMS value of the noise contaminating the MUPs. Based on these distances and using χ^2 statistics, MUPs with inconsistent shapes are detected and classified based on shape as: *definitely* a FCE if $d_i >$ $\chi^2(5,0.01)$ and *potentially* a FCE if $d_i > \chi^2(5,0.05)$. In the second step, erroneous MUPs are detected using firing pattern information. MUPs that cause IDI inconsistencies are identified and classified into three categories based on firing pattern as : *definitely* a FCE if $\mathbf{IDI}_i < \mu - 3\sigma$, *potentially* a FCE if $\mathbf{IDI}_i < \mu - 2\sigma$, and *do not know* if $\mathbf{IDI}_i > 2\mu$. Where μ and σ are the estimated mean and standard deviation of the IDIs of the given train. In the third step, a MUP is categorized as a FCE if it was assigned into either 1) the *definitely* a FCE based on shape class, or 2) the *potentially* a FCE based on shape class AND the *do not know* based on firing pattern class, or 3) the *potentially* a FCE based on shape class AND the *potentially* a FCE based on firing pattern class.
RESULTS: Forty-three 30s long simulated EMG signals with different levels of intensity (24-93 pps), MUP shape stability (with jitter values from 50-150μs) and IDI variability (CV from 0.10-0.45) were generated [1]. Up to 20% MUP FCE errors were randomly added to otherwise error-free trains extracted from the simulated EMG signals. Sensitivity, specificity and accuracy in categorizing the MUPs of a MUPT are summarized in Table 1. As shown, the algorithm could detect most of the FCE errors added to the trains and was also able to correctly classify most of the MUPs that indeed belonged to the trains.
CONCLUSION: A robust method for identifying MUPs erroneously assigned to a MUPT extracted during EMG signal decomposition is presented. The results based on simulated data show that the ability of the algorithm to correctly classify the MUPs assigned to a MUPT is encouraging. This accuracy, on average, was 92.1%. The results are encouraging and suggest that using these methods can improve EMG signal decomposition results by improving estimates of MUP shape, and MU firing patterns.
REFERENCES:
1. Hamilton-Wright A., Stashuk D.W. (2005), IEEE Trans. on Biomed. Eng., 52(2) 171-183.

Table 1: Accuracy in classifying the MUPs of a MUPT correctly.

Term	**Sensitivity**	**Specificity**	**Accuracy**
Accuracy (%)	84.4±0.7	93.4±0.1	92.1±1.0

SUPERFICIAL NECK MUSCLE SYNERGY DURING HEADRAISE EXERCISES IN INDIVIDUALS WITH CHRONIC NECK PAIN OF A TRAUMATIC AND NON-TRAUMATIC ONSET

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AIM: The aim of this study was to determine whether muscle activity differed in individuals with chronic neck pain of a traumatic onset (TO, *n* = 4*)* or non-traumatic onset (NTO, *n* =13*)* compared to healthy controls (HC, *n* = 18) in the upper trapezius (UTRP) and sternocleidomastoid (SCM) muscles during a sustained head raise task. The SCMs are directly recruited in the head raise activity whereas, the UTRPs could be recruited to stabilise the head raise position when muscles directly involved become fatigued.
METHOD: Subjects performed a head raise from a supine position, with cervical flexion, to a height of 1 – 1.25 cm and maintained the position until fatigue resulted in the head dropping below the required height. Simultaneous recordings of the UTRPs and SCMs were obtained using 4-channel linear array electrodes Global root-mean-square (GRMS) and Global median frequency (GMDF) were estimated and changes over time, as well as differences between the groups, were investigated.

RESULTS: All groups showed increasing GRMS and decreasing GMDF values over time in the SCMs with no significant differences or observable trends between the groups. The HC and NTO groups showed increasing activity of the UTRPs during the exercise. The TO group showed a trend for less of an increase in GRMS values in the right UTRP ($p<0.285$) compared to the HC and NTO groups (figure 1).

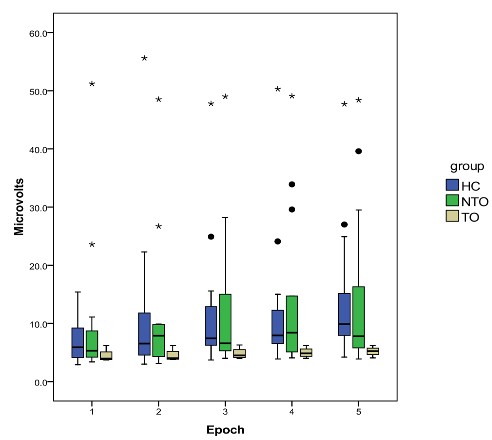

Figure 1: RMS activity of the right UTRP over 5 epochs

CONCLUSION: The results show that SCM activity did not differ during the sustained head raise exercise between the groups. Increasing UTRP activity was seen in the HC and NTO groups, possibly to help stabilise the head raise position when the muscles directly involved became fatigued. The small TO group size mean the results should be interpreted with caution. However, the lower GRMS values and reduced increase in these values in the right UTRP suggest that the TO group did not employ this muscle as much as the HC and NTO groups, possibly due to the muscle being painful or an increased reliance upon the flexor muscles in maintaining this position. These results could also indicate that the recruited motor units in the UTRPs of the TO group were more fatigue resistant than those in the HC and NTO groups.

SUPERFICIAL NECK MUSCLE SYNERGY DURING ARM RAISE EXERCISES IN INDIVIDUALS WITH CHRONIC NECK PAIN OF A TRAUMATIC AND NON-TRAUMATIC ONSET

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AIM : The aim of this study was to determine whether muscle activity differed in individuals with chronic neck pain of a traumatic onset (TO, *n* =4*)* or non-traumatic onset (NTO, *n* =13*)* compared to healthy controls (HC, *n* =18) in the upper trapezius (UTRP) and sternocleidomastoid (SCM) muscles during a sustained arm raise task. The UTRPs are directly recruited in the arm raise activity whereas, the SCMs could be recruited to stabilise the arm raise position when muscles directly involved become fatigued.
METHODS: Subjects performed bilateral shoulder abduction to 90 degrees and maintained the position until fatigue resulted in the arms dropping below 90 degrees. Simultaneous recordings of the UTRPs and SCMs were obtained using linear array electrodes and motor unit action potentials (MUAPs) were detected from the recorded signals using an algorithm based on the Continuous Wavelet Transform. Global root-mean-square (GRMS), Motor unit action potential root-mean-square (MRMS, related to the size of the motor unit and its depth beneath the skin) and motor unit action potential rate (MR, the number of MUAPs per second, indicating the input from the CNS to the muscle) were estimated and changes over time as well as differences between the groups were investigated.
RESULTS: In the right UTRP higher MR ($p< 0.075$) and lower MRMS ($p<0.042$) were seen in the TO group compared to the HC and NTO groups. In the left UTRP higher MR values ($p< 0.011$) and a trend for lower MRMS ($p<0.134$) were seen in the TO group as compared to the HC and NTO groups. All groups showed increasing activity of the SCMs during the exercise. In the right SCM the TO group showed lower values for GRMS ($p<0.027$) and MRMS ($p< 0.042$) and a trend for lower MR values ($p<0.184$) as compared to the HC and NTO groups.
CONCLUSION: The lower MRMS and higher MR values in the UTRPS seen in the TO group suggest a greater proportion of small, low-threshold MUs, which are activated more frequently. This could result from these muscles being employed in a more postural role due to fear avoidance, as a result of pain. Increasing SCM activity was seen in all groups, possibly to help stabilise the arm raise position when the muscles directly involved became fatigued. The small TO group size mean the results should be interpreted with caution. However, the reduced GRMS, MRMS and MR values in the right SCM suggest the TO groups did not employ this muscle as much as the HC and NTO groups, possibly due to the muscle being painful or an increased reliance upon the UTRPs in maintaining this position.

COMPARISON OF SITTING ON A GYM BALL ALONE VERSUS SITTING ON A GYM BALL PLUS DYNAMIC LIMB MOVEMENTS FOR CHRONIC BACK PAIN: A 6-MONTH FOLLOW-UP CLINICAL TRIAL

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AIM: To compare the effects of two spinal stabilizing exercise programs; a “sitting on a gym ball alone” program (program A) with a “sitting on a gym ball plus dynamic limb movements” program (program B) for the decrease of disability and pain intensity at 6 months in patients with chronic low back pain (LBP).

METHODS: Forty patients with chronic LBP were randomly assigned either program A (n = 20) or program B (n = 20) and were asked to perform the prescribed exercise at home for at least 20 minutes per day, 5 days per week for 8 weeks. The primary outcomes were changes in the score on the Roland-Morris Disability Questionnaire (RMDQ) and the numerical pain rating scale at 6 months (NRS).

RESULTS: All subjects reached 6-month follow-up. Age, weight, height, body mass index, level of functional disability and current pain intensity were similar between the two groups at baseline. After 6 months, the decrease in disability scores were 3 (1, 4) in group A and 5 (2.3, 7) in group B, while the decrease in pain intensity score were 3.5 (3, 4.8) in group A and 3 (2.3, 4) in group B (Table 1). When the baseline and the follow-up scores were compared, Wilcoxon signed ranks test demonstrated the statistically significant changes of disability and pain intensity for both groups (p<0.0001). Moreover, Mann-Whitney *U* test showed that subjects in a program B group were more likely to have a greater decrease in disability than those in a program A group (p=0.049).

CONCLUSION: The two 8-week spinal stabilizing exercise programs were proved to reduce pain and disability in patients with chronic LBP. Evidently, the benefits were maintained at a long-term follow-up. Sitting on a gym ball might facilitate spinal stabilizing muscle function as well as activate balance and proprioception. Further studies regarding the use of more objective outcome measurements are necessary to provide evidence on the change of trunk musculature activity after the application of this specific type of exercise intervention.

Table 1: Comparison of the RMDQ and NRSW scores between Group A and Group B

Outcome measure	Group A				Group B			
	Pre test	Post test	Within-subject comparison (p-value)	Change score at follow-up	Pre test	Post test	Within-subject comparison (p-value)	Change score at follow-up
RMDQ Median (Q_1,Q_3)	3.5 (2,5)	0.5 (0,4)	<0.001*	3 (1,4)	5.5 (3,7.8)	0.5 (0.5,1)	<0.001*	5 (2.3,7)
NRS Median (Q_1,Q_3)	4 (3,5)	0 (0,1)	<0.001*	3.5 (3,4.8)	4 (3,5)	0 (0,2)	<0.001*	3 (2.3,4)

* p-value from Wilcoxon signed ranks test, significant difference at p<0.05

A FREQUENCY RESPONSE MODEL OF SKELETAL MUSCLE AND BIOCHEMICAL PROPERTIES REFLECTED BY THE MODE ELEMENTS

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AIM: The aim of the present study was to estimate a frequency response model of skeletal muscle from isometric twitch force evoked by a single electric impulse and to clarify the relationship between the model elements and biochemical properties of the skeletal muscle.
METHODS: Five healthy males (age 23.0±1.2 years) participated in this study. In the experiment, single twitch contraction of the biceps brachii muscles was elicited by the supramaximal stimulation with 0.5 ms square-wave pulse. The Bode diagram of the twitch force signal was calculated by the fast Fourier transform algorithm. Then, the frequency response model of skeletal muscle during isometric twitch contraction was estimated by best-fitting to the Bode diagram of the twitch force signal.
RESULTS: The Bode diagram of the force signal demonstrated an aspect of the low-pass filter. The frequency response model was described by a frequency transfer function consisting of a proportional element (K), three first-order lag elements (τ_1, τ_2, τ_3) and a dead time element (L). In addition, the three time constants included in the model showed a specific relation to the twitch force parameters (i.e. the delay time (T_d), the contraction time (T_c) and the half relaxation time ($T_{1/2}$)). Namely, two time constants τ_1 and τ_2 correlated closely with the delay time T_d and contraction time T_c corresponding to the period when free sarcoplasmic calcium concentration changed rapidly, then led to force production. In contrast, the third time constant τ_3 correlated positively and strongly with only the half relaxation time $T_{1/2}$ which reflected the decline time constant of the twitch force determined by viscoelastic property of skeletal muscle while the free sarcoplasmic calcium concentration almost steady at the resting level.
CONCLUSION: These results suggest that the individual elements in the frequency response model reflect the biochemical and biomechanical properties in the excitation-contraction coupling process of skeletal muscle.

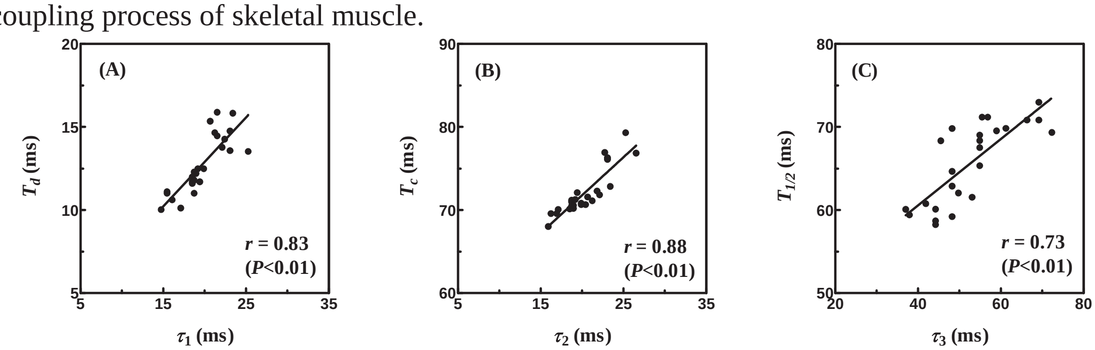

Figure: Relationships between time constants (τ_1, τ_2 and τ_3) and delay time (T_d), contraction time (T_c) and half relaxation time ($T_{1/2}$), respectively.

REGULATION OF PRECISION IN POSITIONING OF THE TRUNK

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AIM*:* The aim of this study was to examine how precision is regulated in trunk postural control. Previous studies have shown that increased precision demands on the control of posture or movement of other body segments are associated with increased joint stiffness caused by antagonistic co-activation. Due to the large mass (and thus high inertia) of the trunk and the complexity of the trunk musculature, which sub-serves multiple functions (e.g. posture and breathing), it is not obvious that similar strategies are used in the trunk. The trunk is involved in almost all human movements and precise control is needed even for simple daily life activities. Furthermore, insight in mechanisms contributing to precision control of the trunk, may improve our knowledge of impaired motor control in low-back pain patients.
METHODS*:* Thirteen subjects performed static postural tasks, aiming at a target object with a cursor that responded to 2D trunk angles. By manipulating target dimensions, different levels of precision were imposed in the frontal and sagittal planes. Visual feedback was given when subjects failed to stay within the target. Trunk orientation and electromyography (EMG) of abdominal and back muscles were recorded.
RESULTS*:* Repeated measures ANOVAs revealed significant effects of target dimensions on kinematic variability in both movement planes. Specifically, SD of trunk angle decreased significantly when target size in the corresponding direction decreased, regardless of the precision demands in the other direction. Thus, precision control of trunk posture was directionally specific. No consistent effect of precision demands was found on trunk muscle activity, when averaged over time series. However, significant correlations were found between EMG linear envelopes averaged over muscle groups and kinematic time series, especially when precision demands were low. Furthermore, appropriate responses to the appearance of visual feedback were found, in that EMG activity in muscle groups accounting for trunk angle adjustments in the correct direction increased.
CONCLUSION*:* It was concluded that feed forward antagonistic co-activation to increase trunk stiffness was not used as strategy to meet increased precision demands in trunk postural control. Instead, the data suggest that precision of trunk angle was controlled in a feedback mode. Previous studies showed that subjects respond to external mechanical perturbations of trunk posture by increasing co-activation and that patients with low-back pain use the same strategy, apparently to enhance spinal stability. The finding that precision of trunk postural control does not coincide with antagonistic co-activation suggests that physiological costs associated with this strategy may be substantial.

KINEMATIC ANALYSIS OF CHANGED MOVEMENT BEHAVIOR IN CERVICAL ARTHRODESIS PATIENTS

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AIM : Comparative analysis of the range of motion and the movement patterns in patients with an anterior cervical fusion according to the method of Smith-Robinson and in a control group of healthy subjects.
METHODS: Movement patterns of 50 subjects in the experimental group and 50 control subjects were registered by means of an electromagnetic tracking device (Flock of Birds). Movement patterns were analysed using different kinematic parameters describing the range of motion, the cross-correlation between main and coupled motion components, the ratio between the magnitude of motion components and the smoothness of the movement (jerk index).
RESULTS: Comparing the kinematic results of the experimental group with the control group reveals that the cross-correlation, the ratio, the range of the main motion component and of the range of the coupled lateral bending and axial rotation motion components differ significantly ($p<0.01$) both during active axial rotation and during active lateral bending movements. Between the experimental and the control group the jerk index (derivative of the acceleration) of the main motion component is significantly different during active axial rotation as well as during active lateral bending ($p<0.05$). However, the jerk-index of the coupled motion components is not significantly different in the experimental subgroups compared to the control group.
CONCLUSION: Subjects who have an anterior cervical fusion according to the method of Smith-Robinson show significant differences in cervical kinematics during active axial rotation and lateral bending movement compared to control subjects.

FRACTAL THEORY BASED FEATURE FOR MEASURING LOW-LEVEL MUSCLE ACTIVATION

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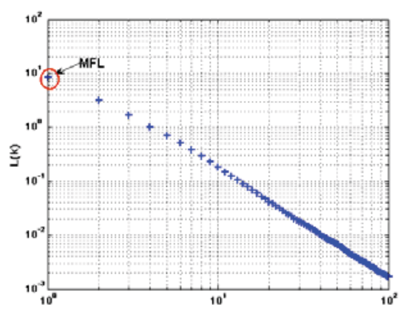
AIM: This study has proposed a new fractal based feature of sEMG, maximum fractal length (MFL). MFL is based on the logarithmic length of the signal at the lowest scale. The results of the experiments indicate that MFL of sEMG is a reliable ($p<0.001$) measure of strength of muscle contraction even when muscle activity is only 20% MVC.
METHODS: Experiments were conducted with 7 participants, where sEMG from the forearm (FDS) muscle was recorded when the participant maintained specific finger flexion. The first step of the analysis required the computation of maximum fractal length (MFL) of sEMG using fractal dimension algorithm (refer Figure. 1) for a window size of 1024 samples. The results of the experiments were analyzed statistically to determine the significance between the force of contraction and the value of MFL. This was repeated for RMS of sEMG and force of contraction.
RESULTS: The result (Table 1) shows that values of MFL are a good indicator of the force of contraction of the muscles for all levels of muscle contraction. RMS of sEMG is an indicator of the force of contraction only when the level of contraction is high (80% MVC) but a poor indicator of the force of contraction when the level of contraction is low (20%). From Figure. 2, it is observed that MFL is reliably able to differentiate between force of little finger flexion- 20%, 50% and 80% MVC.
CONCLUSION: This study has identified and confirmed a new fractal based feature of sEMG which is closely related to the strength of the muscle activation even when the level is very low. The experimental results have demonstrated that MFL can be used to identify small changes in muscle activity and a good measure than RMS even when the strength of contraction is only 20% MVC ($p<0.001$).

Table 1: p values from two sample t- test.

	20% MVC		**50% MVC**		**80% MVC**	
Gestures	**MFL**	**RMS**	**MFL**	**RMS**	**MFL**	**RMS**
Little and Ring	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Ring and Middle	0.001	0.19	0.001	0.104	0.0001	0.001
Little and Middle	0.0001	0.01	0.0001	0.0001	0.0001	0.0001



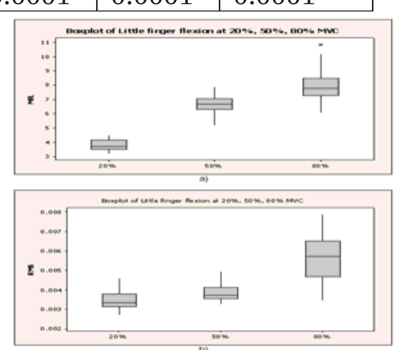


Figure 1: Determining MFL. **Figure 2:** Box plot of Little finger flexion for MFL and RMS.

INDEPENDENT COMPONENT APPROACH TO MUSCLE FATIGUE ASESSMENT DURING DYNAMIC CONTRACTIONS

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AIM: Spectral compression of surface electromyogram (sEMG) is associated with onset of localized muscle fatigue. The spectral compression has been explained based on motor unit synchronization theory. According to this theory, motor units are pseudo randomly excited during muscle contraction, and with the onset of muscle fatigue the recruitment pattern changes such that motor unit firings become more synchronized. While this is widely accepted, there is little experimental proof of this phenomenon. This paper has used source dependence measures developed in research related to independent component analysis (ICA) to test this theory.
METHODS: Five healthy subjects participated in the trial. The experimental protocol was approved by Ethics Committee of RMIT University. One pair of electrodes was placed on either side of Biceps muscle to get two-channel recording of sEMG. The subjects performed dynamic contractions using fixed standard load. The load was chosen to be about 75% maximum voluntary contraction. The sEMG was recorded until the subject complained of muscle fatigue. The typical time period of each recording was 180 seconds.
RESULTS: Preliminary analysis of the RMS values calculated from the separated sources (Table 1) shows a general trend of increasing amplitude after fatigue for dynamic contraction data. However, the RMS value alone does not reveal much about the synchronicity of the motor units, only that the work required to produce the same force is increasing as the muscle becomes fatigued. However from ICA Global matrix analysis it is clear that the values of determinant for all subjects are close to unity before fatigue, the determinant values are close to zero once the subject gets fatigued. This shows that when the muscle is not fatigued, the sources are independent, and when the muscle is fatigued, the sources are dependant and in synchronization.
CONCLUSION: During fatigue it is reported that increased effort is required to sustain the same force level. This can be observed as increase in RMS of the separated sources during fatigue conditions. But the property of the signal which is reflected as RMS does not vary much. Hence to identify the changes in the fatigued state, the dependency between the sources were analyzed. The results show that sources are dependent when muscle gets fatigued and are not dependant when the muscle is not in fatigue state. This states that dependency properties can be used to analyze the onset muscle fatigue. As a future work, this analysis can be further expanded to identify the synchronization of the motor units during various muscle activities, such as isometric muscle contractions.

Table 1: Mean values of ICA-RMS and the determinant of Global matrix before and after dynamic contraction.

Subject	ICA-RMS values		ICA-Global matrix values	
	Before fatigue	**After Fatigue**	**Before fatigue**	**After Fatigue**
1	1.0476	1.5573	0.7619	0.0015
2	1.0005	1.4577	0.7684	0.0012
3	1.0455	1.5573	0.7856	0.0013
4	1.0498	1.5602	0.7731	0.0016

A THREE-DIMENSIONAL BALANCE CONTROL MODEL OF QUIET UPRIGHT STANCE BASED ON AN OPTIMAL CONTROL STRATEGY

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AIM: Many existing balance control models have focused on investigating postural sway only in the sagittal plane. However, evidence indicates that postural sway in the frontal plane is important, and able to account for different balance control mechanisms as well. The purpose of this study was to develop a three-dimensional balance control model that can simulate postural sway in both the sagittal (A/P direction) and frontal (M/L direction) planes.
METHODS: In the model, the human body was represented as a two-segment inverted pendulum, in which there are two joints representing the ankle and hip. In order to linearize body dynamics, several assumptions were made, for example that there was no axial rotation during quiet upright stance. Sensory systems were assumed to be a time delay unit. The neural controller was assumed to be an optimal controller that generates ankle and hip control torques to minimize a performance index defined by physical quantities relevant to sway in both the A/P and M/L directions. An optimization procedure, whose cost function was defined by a scalar error between the simulated and experimental center of pressure (COP) based measures, was performed to determine unspecified model parameters. Simulated COP-based measures were normalized by their experimental references, and 95% confidence intervals of these normalized measures were calculated and used to evaluate the proposed model in terms of its ability to simulate postural sway. The dependent COP-based measures include root mean square displacement (RMS), mean velocity (MV), centroidal frequency (CFREQ), frequency dispersion (FREQD), transition time (TT), transition amplitude (TA), short term scaling exponent (H_S), and long term scaling exponent (H_L).
RESULTS AND CONCLUSION: For all dependent COP-based measures, 95% confidence intervals of the normalized simulated values included unity (Fig. 1), indicating that there were no significant differences between experimental and simulated COP-based measures. Thus, the proposed model appears able to accurately simulate postural sway behaviors. We may conclude that the proposed model is valid at least to some extent, and thus can be used to further investigate balance control mechanisms, for example how individual differences and task conditions (e.g. aging and localized muscle fatigue) affect balance control.

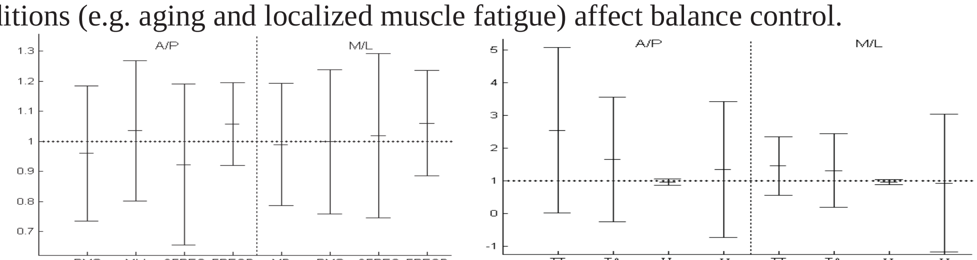

Figure 1: Mean and 95% confidence intervals of the normalized simulated COP-based measures. Experimental references used for normalization are given in Table 1.

Table 1: Experimental COP-based measures

		RMS	MV	CFREQ	FREQD	TT	TA	H_S	H_L
A/P	Mean	6.68	10.52	0.549	0.903	0.579	26.33	0.817	0.198
	SD	2.95	3.55	0.139	0.061	0.297	26.23	0.041	0.100
M/L	Mean	6.31	13.08	0.582	0.844	0.477	34.35	0.829	0.148
	SD	2.19	4.95	0.153	0.079	0.122	31.50	0.030	0.109

SURFACE EMG SIGNAL DECOMPOSITION AND PATTERN CLASSIFICATION FOR DIFFRERNT MVCS: AN APPROACH USING SOURCE SEPARATION TECHNIQUES

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AIM: This research reports a new technique of signal decomposition and pattern classification for surface electromyography (sEMG) using source separation technique. The technique uses blind source separation (BSS) methods such as Independent Component Analysis (ICA) to classify the low level Myo-electrical signals during different Maximum Voluntary Contraction (MVCs).
METHODS: Three different finger gestures (*Middle finger flexion, Ring finger flexion and Little finger flexion*) were used as protocol to record sEMG from the participant using Delsys EMG acquisition equipment. The participants were asked to maintain each flexion for 7-8 seconds for three different levels of forces i.e., 20%, 50% and 80% of MVCs. The force of contraction was measured using *FlexForce* sensor (*FlexiForce* A201, Tekscan, Boston, MA, USA).
RESULTS: The results were summarized in Table 1. From Table 1, it is observed that there is large increase in ICA RMS (mean values) for different finger flexion as the force of contraction increases from 20% MVC to 80% MVC for all subjects. But the mean values of RMS have a marginal increase or no increase up to 50% MVC. The results show that values of RMS after ICA (ICA RMS) are a good indicator of the force of contraction of the muscles for all levels of muscle contraction. RMS of sEMG is an indicator of the force of contraction only when the level of contraction is high (80% MVC) but a poor indicator of the force of contraction when the level of contraction is low (20%). This may be attributable to the effect of the background activity during low-level muscle activity.
CONCLUSION: From the outcomes of this research, it is evident that the patterns of sEMG against 3 different finger flexion actions for different MVCs were similar (statistical significance, $p>0.01$), while after separation using ICA, there is a clear identification of patterns (statistical significance, $p<0.0001$) related to MVCs. This paper has compared the methods of identifying patterns at various levels of force (MVCs) using sEMG without separation and using sEMG after separation using ICA. The similar patterns for different MVCs using non-separated sEMG are attributable to the high level of cross-talk, noise and low signal strength. ICA overcomes this shortcoming and the results clearly show that there is clear separation of patterns of sEMG during various levels of MVCs.

Table 1: Overall (mean) classification results for 20%, 50% and 80% MVCs of sEMG using ICA separated sources and raw sEMG signal

		20% MVC		**50% MVC**		**80% MVC**	
	Gestures	**ICA RMS**	**EMG RMS**	**ICA RMS**	**EMG RMS**	**ICA RMS**	**EMG RMS**
Ch1	Little	2.901	0.0253	5.462	0.0343	9.799	0.133
	Ring	3.167	0.0287	6.544	0.0347	10.125	0.151
	Middle	3.026	0.0265	6.006	0.0346	10.357	0.176
Ch2	Little	3.054	0.0242	6.255	0.0321	10.092	0.139
	Ring	3.274	0.0279	6.501	0.0319	9.971	0.188
	Middle	3.234	0.0276	6.304	0.0308	10.361	0.172

PELVIC FLOOR AND ABDOMINAL MUSCLE CONTRIBUTIONS TO THE GENERATION OF URETHRAL PRESSURE

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AIM: Urethral pressure increases are generated through a combination of urethral sphincter contraction, pelvic floor muscle (PFM) contraction and increases in intra-abdominal pressure generated by diaphragmatic and abdominal muscle contraction. The purpose of this study was to describe the relationships among abdominal and PFM contraction and urethral pressure rises during PFM maximum voluntary contractions (MVCs) and during coughing in women.
METHODS: Urethral pressure was recorded using a saline-filled, 8 French catheter positioned where the transducer recorded the highest pressure values during both a PFM MVC and a cough. Electromyographic (EMG) data were recorded from the PFMs using a Femiscan™ vaginal probe and from the rectus abdominis (RA), external obliques (EO) and internal obliques (IO) muscles using Delsys™ D.E.2.1 surface electrodes. The volunteers performed three trials of a PFM MVC in supine and in standing and three trials of a maximum effort cough in standing. All data were smoothed using a 3rd order Butterworth filter and normalized to the peak smoothed amplitude achieved during each trial. Peak pressures were compared among the tasks using an analysis of variance. Ensemble average urethral pressure versus EMG curves were computed.
RESULTS: Eleven women (median age 42, range 29 to 68 years) participated. Six volunteers reported stress urinary incontinence and eight reported urgency and/or urge incontinence. Higher rises in urethral pressure were produced during coughing than during the PFM MVCs (286 ± 138 cmH_2O and 177 ± 137 cmH_2O respectively, $p<0.001$). During the PFM MVCs the relationship between the rise in urethral pressure and PFM EMG activity was weak and curvilinear, as was the relationship between IO activity and urethral pressure. (See Figure 1.) There was no association between the rise in urethral pressure and RA or EO EMG. During coughing, all of the urethral pressure versus EMG curves demonstrated strong curvilinear relationships.
CONCLUSION: Coughing produces larger rises in urethral pressure and much stronger associations between abdominal and PFM contraction and rises in urethral pressure than do PFM MVCs. These results suggest that the abdominal and the PFMs contribute more to the generation of urethral pressure during coughing than during voluntary PFM contractions. Further research is needed to understand when abdominal muscle contractions contribute to the generation of urethral pressure and when they provoke urinary incontinence.

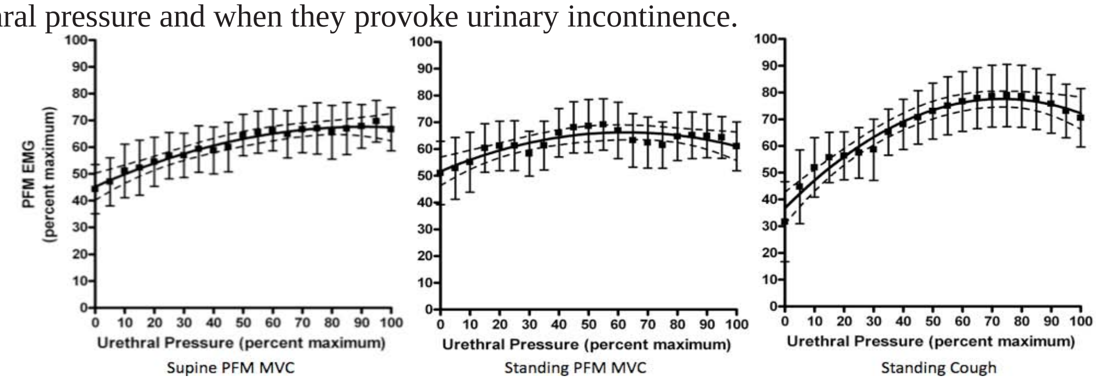

Figure 1: Urethral pressure generation versus PFM EMG curves during the three tasks.

UNRAVELING THE NEUROPHYSIOLOGY OF MUSCLE FATIGUE

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Despite 100 years of research since the seminal work of Angelo Mosso (1846-1910), our understanding of the physiological mechanisms responsible for muscle fatigue remains rather rudimentary. Most investigators recognize that one of the major impediments to increasing our knowledge on muscle fatigue is the pervasive influence of task requirements on the dominant mechanisms that limit performance during sustained activities (Enoka & Stuart, 1992).

The presentation will focus on an approach that uses the task specificity of muscle fatigue to identify the adjustments that limit the duration a submaximal contraction can be sustained. The experiments involved measuring the time to failure of a sustained contraction as the compliance of the load against which the limb acted was varied. The results have indicated that the control of limb position (position control) places a greater demand on the central nervous system than does the requirement to exert a comparable net muscle torque against a rigid restraint (force control) (Enoka & Duchateau, 2008).

Although the decline in MVC force was similar at task failure for fatiguing contractions that involved either force or position control, the rates of change in the amplitude of the surface EMG, mean arterial pressure, heart rate, perceived exertion, and fluctuations in motor output were greater during position control (Hunter et al. 2002; Maluf et al. 2005; Rudroff et al. 2007). When the activity of motor units was recorded during the two control strategies, the same motor units exhibited greater decreases in mean discharge rate and greater increases in the variability of discharge times during position control (Mottram et al. 2005). To sustain the same target force, therefore, the motor unit pool was recruited more rapidly and task failure occurred sooner during position control (Maluf et al. 2005; Mottram et al. 2005).

As reflex responsiveness increases more rapidly during position control (Akazawa et al. 1983), recent work has examined the responsiveness of descending and peripheral afferent pathways to explain the differences in synaptic input received by the motor neuron pool during the two control strategies (Klass et al. 2008). The more rapid development of muscle fatigue during position control appears to involve a greater modulation of Ia afferent activity and a requisite compensation by descending inputs. These results underscore the significance of the demands placed on the nervous system in limiting the capacity of individuals to perform functional tasks.

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PRE AND POSTACTIVATION EMG BEHAVIOR DURING AN INCREMENTAL RUNNING TEST

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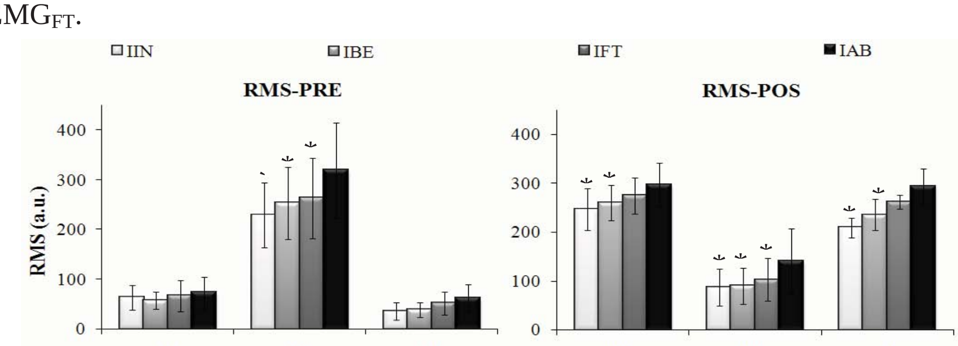
AIM: study electromyographic (EMG) amplitude data of lower limb muscles obtained at preactivation (PRE) and postactivation (POS) periods during different running intensities relatives to EMG fatigue threshold (EMG_{FT}).
METHODS: Eleven physically active male subjects completed an incremental running test on a treadmill. A foot switch placed under right heel determined the foot strike, PRE and POS were determined when root mean square (RMS) reached three times standard deviation before and after the moment of the foot strike. EMG RMS for vastus lateralis (VL), biceps femoris (BF) and gastrocnemius lateralis (GL) was calculated during PRE (RMS-PRE) and POS periods (RMS-POS). EMG_{FT} was calculated for these muscles, by RMS slopes obtained at each speed. Four relative running intensities were considered: initial test speed (8km.h^{-1}-I_{IN}), equivalent to EMG_{FT} (I_{FT}), 15% below (I_{BE}) and 15% above (I_{AB}) EMG_{FT}. The effect of running intensity on RMS was verified by ANOVA for repeated measures, significance level was set at $p<0.05$.
RESULTS: RMS-PRE for BF muscle presented higher values at I_{FT} and I_{AB} when compared to I_{IN} and higher values at I_{AB} when compared to I_{FT}. RMS-POS for VL and BF muscles where higher at I_{AB} when compared to I_{IN} and only for BF when compared to I_{FT}. RMS-POS for GL muscle presented higher values at I_{FT} and I_{AB} when compared to I_{BE} and at I_{AB} when compared to I_{BE} (Figure 1).
CONCLUSION: Intensity does not have any effect on RMS-PRE during incremental running test for VL and GL, suggesting a preprogrammed mechanism which is not altered by metabolic demand. BF muscle is more susceptible to fatigue, so presented additional fiber recruitment earlier at any period analyzed, while VL and GL seems to alter recruitment with higher metabolic cost.
ACKNOWLEDGEMENTS: We would like to thank FAPDF and FAPESP (processes 05/02535-2 and 06/55807-3) for financial support.
Figure 1: Precontact (PRE) and postcontact (POS) root mean square (RMS) obtained for vastus lateralis (VL), biceps femoris (BF) and gastrocnemius lateralis (GL) muscles at four running intensities: initial (I_{IN}), equivalent to EMG_{FT} (I_{FT}), 15% below (I_{BE}) and 15% above (I_{AB}) EMG_{FT}.



*Significant difference when compared to I_{FT} and I_{AB}. ** Significant difference when

LOWER LIMB SPECTRAL EMG CORRELATES TO STRIDE FREQUENCY AT PRE AND POSTACTIVATION PERIODS OF AN INCREMENTAL RUNNING TEST

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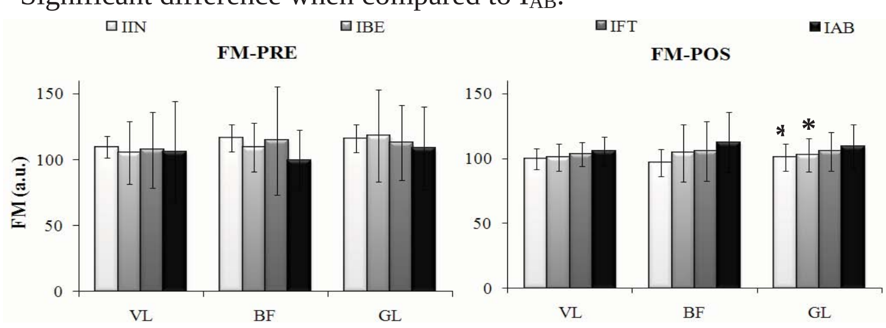
AIM: verify and correlate stride frequency (SF) and electromyographic (EMG) spectral data of lower limb muscles obtained at preactivation (PRE) and postactivation (POS) periods during different running intensities relatives to EMG fatigue threshold (EMG_{FT}).
METHODS: Eleven physically active male subjects completed an incremental running test on a treadmill. A Foot switch placed under right heel determined the foot strike, and allowed the SF calculation. PRE and POS duration (ms) were determined when EMG root mean square reached three times standard deviation before and after the moment of the foot strike. Median Frequency (MF) for vastus lateralis (VL), biceps femoris (BF) and gastrocnemius lateralis (GL) was calculated during PRE (MF-PRE) and POS periods (MF-POS). EMG_{FT} was calculated for these muscles, by RMS slopes obtained at each speed. Four relative running intensities were considered: initial test speed (8km.h^{-1}- I_{IN}), equivalent to EMG_{FT} (I_{FT}), 15% below (I_{BE}) and 15% above (I_{AB}) EMG_{FT}. The effect of running intensity on SF, PRE and POS duration, MF-PRE and MF-POS was verified by ANOVA for repeated measures and correlation verified by Spearman test, significance level was set at $p<0.05$.
RESULTS: Running speed does not affect the PRE period for any muscle, however, POS period for GL decreased at I_{FT} and I_{AB} when compared to I_{IN}. GL muscle is more efficient to use storage elastic energy, decreasing POS duration and increasing fast twitch fiber utilization at higher intensities. I_{AB} presented SF and MF-POS for GL higher than at I_{BE} and I_{IN} (Figure 1). There were significant correlations ($p<0.05$) for SF and MF-PRE of VL at I_{BE} ($r=0.78$) and I_{FT} ($r=0.69$), MF-POS of VL at I_{AB} ($r=-0.77$), MF-POS of BF at I_{IN} ($r=-0.91$) and GL at I_{BE} ($r=-0.74$) and I_{FT} ($r=-0.73$).
CONCLUSION: Preprogrammed mechanisms for VL, BF and GL muscles, could lead to increase SF, improving running economy and shorten contact durations. However, it seems to present specific changes in MF depending on muscle, metabolic demand and stride period.
ACKNOWLEDGEMENT: We would like to thank FAPDF and FAPESP (processes 05/02535-2 and 06/55807-3) for financial support.

Figure 1: Precontact (PRE) and postcontact (POS) median frequency (MF), for vastus lateralis (VL), biceps femoris (BF) and gastrocnemius lateralis (GL) muscles at four running intensities: initial (I_{IN}), equivalent to EMG_{FT} (I_{FT}), 15% below (I_{BE}) and 15% above (I_{AB}) EMG_{FT}. *****Significant difference when compared to I_{AB}.



EFFECTS OF MOMENT DIRECTION AND HEIGHT OF CENTRE OF MASS ON TRANSVERSUS ABDOMINIS ACTIVATION IN STANDING

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AIM: Direction independent timing of activation of transversus abdominis (TrA) observed with arm movements in standing has been taken as an indication of a role of this muscle as a spine stabilizer [Hodges & Richardson 1996]. In support of this, recent experiments have shown direction independency of both timing and level of TrA activation in response to external trunk perturbations in side-lying, a situation with no upright postural demand on the trunk [Eriksson Crommert & Thorstensson 2008, 2009]. However, experiments with external sudden loading in standing, i.e. with a postural demand present, have shown TrA activation patterns that indicate direction specificity [Cresswell *et al.* 1994]. The aim of this study was to attempt to differentiate between moment and posture related trunk muscle activation in standing by applying the same moment on the trunk with either (1) different directions, keeping the postural demand (height of the centre of mass) the same, or (2) the same direction, but with differing postural demand.
METHODS: Eleven healthy male subjects held 3 different bilateral static arm positions with straight arms and a load of 3 kg in the hands (arms in 45° shoulder extension, 45° shoulder flexion and 135° shoulder flexion). Each position was held for 5 s and repeated 3 consecutive times and the order of arm positions was randomized between subjects. Compared to 45° shoulder flexion, holding the arms extended to 45° induced a similar moment in size but in opposite direction, and holding the arms in 135° shoulder flexion produced both similar moment size and direction but increased the height of the centre of mass. Muscle activity was recorded from TrA and obliquus internus (OI) with fine-wire intra-muscular electrodes, inserted under the guidance of real-time ultrasound, and from rectus abdominis (RA) and erector spinae (ES) with surface electrodes. Activity was calculated as root mean square over the 5 s for each position and expressed relative to values obtained from maximal voluntary contractions.
RESULTS: TrA was the only muscle that displayed an unchanged level of activation between the positions of 45° shoulder flexion and extension. OI and RA showed higher activity in shoulder extension and ES in shoulder flexion. Compared to 45° shoulder flexion, raising the arms to 135° shoulder flexion resulted in an increase in activation only of TrA.
CONCLUSION: The finding of similar activation levels of TrA independent of direction of applied moment support the proposed role of TrA as a general stabilizer of the lumbar spine. Furthermore, the selective increase in activation of TrA with an augmented postural demand indicates an additional specific postural function of this muscle.

TOWARDS EMG-DRIVEN MODELS OF MUSCLE-JOINT SYSTEMS FOR CLINICAL APPLICATIONS

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AIM: To assess effects of changes in motor control, coinciding with neurological and musculoskeletal disorders, EMG-driven models of the muscle-joint system under study are necessary. Such models are typically driven with EMG signals normalized to maximum voluntary excitation (MVE). Unfortunately, in patient groups the MVE will generally underestimate true maximum excitation. In the present study, we validated the calibration of an EMG-driven model of the trunk that uses non-normalized EMG as input.
METHODS: Eleven men performed 3 MVE trials and five 5-s static ramp submaximal contractions (0% to 55% of maximum moment) in 6 directions (flexion/extension, left and right lateral bending, left and right torsion) in a dynamometer measuring L5/S1 moments. EMG signals were collected for 8 back and 6 abdominal muscles. An EMG-driven model, consisting of 90 muscle fascicles crossing L5S1 grouped in 14 anatomical units, was used to estimate moments produced by the trunk muscles. Muscle forces were estimated as the product of cross-sectional area, 2-Hz low pass-filtered EMG, a correction for muscle length and a gain per EMG electrode pair, representing maximum muscle tension divided by MVE. Constrained optimization was used to estimate gains (14 estimated parameters) with the RMS difference between measured and predicted moments as cost function. Constraints were based on maximum tension ranging between 20 and 150 Ncm^{-2}, and on MVEs being larger than the maximum EMG in the ramps and lower than 3 times this maximum. Optimization was performed for all ramp contractions at the same time and for all ramps excluding torsion ramps. The optimizations were repeated with additional constraints, guaranteeing ratios of MVEs within 4 synergistic muscle groups (left and right flexors and extensors) to be proportional to the ratios of their mean EMGs and allowing a different maximum tension for flexors and extensors (6 estimated parameters).
RESULTS: Model fit was generally adequate for flexion/extension (mean $r^2 = 0.86$) and lateral bending moments (mean $r^2 = 0.79$), but not for torsion moments (mean $r^2 = 0.37$). Optimization without the additional constraints yielded gains that in several cases equaled upper or lower bounds, due to covariance between EMG amplitudes of different muscles within synergistic groups. The additional constraints solved this problem. Estimated MVEs and true MVEs were not significantly different and were reasonably correlated ($r = 0.63$).
CONCLUSION: A non-normalized EMG model of the trunk muscles provided estimates of muscle forces and moments that are comparable to those obtained using normalized EMG. This allows EMG-driven modeling in populations that are unable to attain true maximum muscle excitation. However, the number of parameters estimated in the optimization must be adjusted to the amount of independent information (covariance between EMG signals) in the calibration data set. The current model, in spite of its detailed, state-of-the-art anatomical basis, does not allow adequate modeling of torsion.

RELIABILITY AND METHODOLOGICAL ISSUES OF THE VISUALLY-TRIGGERED STEP INITIATION TEST

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AIM: Measurement of the speed of step initiation is routinely used in sport and clinical practice. However, most of these tests are based on pre-planned steps and there is no perceptual component, such as reaction on given stimulus. Therefore the aim of the study was to estimate the reliability of novel visually-triggered step initiation test.
METHODS: A group of 91 healthy students (age 21.1 ± 3.9 y, height 181.4 ± 8.2 cm, weight 75.3 ± 10.6 kg) performed repeatedly in two different days 3 trials of simple stepping reactions to visual stimulus. The test began with the subject standing on two mattresses placed in front of the light signal. On the light switch the subject performed two steps (starting with dominant leg) to mattresses (with 30 cm sides) marked with tape on a floor with a 60-70 cm distance in-between. Subjects were instructed to perform the steps as fast as they could. The time of foot off (onset of unloading) and foot contact time (from foot-off to foot-contact) of the first step were recorded by means of the FiTRO Reaction Check. Concurrently with measurement of the reaction times (RT), the speed of step initiation (v_{max}) was measured using FiTRO Dyne Premium, the system based on precise analogue velocity sensor with sampling rate of 100 Hz. The device was anchored to the wall and its nylon tether to the ankle of the subject. His/her task was to perform the step while pulling a nylon tether of the device. In both tests, the best score of 3 trials was used for the analysis. In order to eliminate the learning effect, subjects were allowed to practice the measurement procedure beforehand. Reliability of the test was determined by test-retest correlation coefficients and measurement error. Paired sample t-tests were used to determine if significant differences exist for RT between trials and test sessions. Significance level was set at $\alpha = 0.05$.
RESULTS: Results showed no significant differences between trials in the time of foot off (637.6 ± 99.7 ms, 615.8 ± 76.7 ms, and 624.3 ± 80.8 ms, respectively), foot contact time (492.6 ± 71.2 ms, 484.3 ± 62.9 ms, and 489.9 ± 69.7 ms, respectively), and speed of step initiation (197.8 ± 30.8 cm/s, 204.6 ± 25.8 cm/s, and 204.7 ± 24.9 cm/s, respectively). The best score was achieved in the second trial. As expected, a significant relationship between the foot contact time (from foot-off to foot-contact) and maximal velocity of the step was found ($r = 0.837$). Analysis of repeated measures showed measurement error of 12.2 % for time of foot off (T1) and 11.8 % for foot contact time (T2). Test-retest correlation coefficient between repeated measurements in different days was 0.517 for T1 and 0.534 for T2. The time differences between repeated measurements were significant ($p \leq 0.01$) for T1 (from 641.5 ± 87.3 ms to 600.3 ± 60.0 ms) but not for T2 (from 470.5 ± 63.0 ms to 465.7 ± 54.5 ms).
CONCLUSION: Though including perceptual component into the step initiation test might better reflects real-life situations, problematic reproducibility and lack of the precision outside of the acceptable limits, when compared to accurate laboratory tests, limits the visually-triggered step initiation test to be a viable alternative to currently used methods, namely for quantifying slight changes in performance of individuals and small groups.

COMPARISON OF BODY COMPOSITION AND SOMATOTYPE OF JAPANESE PROFESSIONAL GOLFERS

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AIM: The aim of this investigation was to compare the physical characteristics and somatotype of male and female tournament professional golfers in Japan.

METHODS: The subjects participating in the study were 11 male and 13 female professional golfers for a total of 24. They were somatotyped, following the Heath-Carter anthropometric method. There are 10 items for establishing a measurement. A *t*-test for the statistical analysis was conducted to determine if significant differences existed between male and female professional golfers categorized by class. Selected variables described body size and somatotype. Discriminant function analysis (DFA) using the method of Wilks' lambda was employed to determine which combination of variables best distinguished male and female professional gofers.

RESULTS: Figure 1 shows the somatocharts of male and female professional golfers and the mean values of the somatotypes. The results of the mean somatotypes showed that male golfers (3.8-5.8-1.6), female golfers (4.6-5.8-1.5) were endomorphic mesomorph, respectively. Significant differences (t-tests) were found between male and female professional golfers for: standing height, body weight, triceps skinfold, biceps girth, calf girth, femur width, and FFM ($P<0.001$). The anthropometric variables best discriminated between male and female professional golfers.The results indicated that the combination of standing height, humerus width and femur width was significantly different between male and female golfers ($F_{3, 25} = 8.97$, $P<0.001$; Wilks' lambda = 0.48). When these variables were used to classify the cases, 73 % were correctly classified as describing male golfers, and 94 % were the correct classification for female golfers, with an 86 % correct classification for the total. The results for male and female professional golfers indicated that the combination of body weight, supraspinale skinfolds and BMI were best described across levels ($F_{3, 25} =10.11$, $P<0.001$; Wilks' lambda = 0.45). Altogether, 90 % of the cases were correctly classified, with 82 % and 94 % correct for male and female professional golfers, respectively.

CONCLUSION: Somatotypes of Japanese male and female professional golfers tend toward high mesomorphy. The results suggested that the thickness of limbs of golfers was related to male and female professional golfers.

ACKNOWLEDGEMENTS: The authors wish to express our heartfelt thanks to Professor Emeritus Dr. J. E. Lindsay Carter of San Diego State University for his numerous helpful suggestions.

Professional male golfers　　Professional female golfers

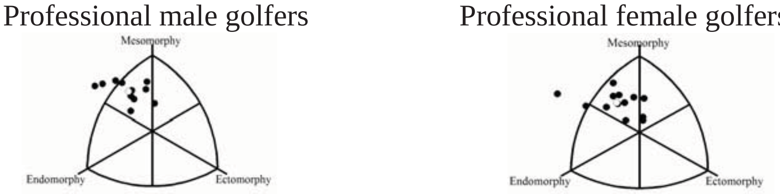

Figure 1: Somatotype distribution of professional male and female golfers. One dot for each player. ○: mean somatotype.

PHASE MODULATION OF THE SHORT LATENCY CROSSED SPINAL RESPONSE IN THE HUMAN SOLEUS MUSCLE

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AIM: Short latency spinally mediated interlimb coordination was recently observed in the human lower limb (Stubbs and Mrachacz-Kersting, 2009 *J Neurophysiol* 102: 3596). However, the response was only observed in sitting and the functional implications remain unknown. The aim of this study was to establish if spinally mediated crossed inhibition is *1.* Observed during the human gait cycle *2.* Modulated during the gait cycle.
METHODS: Two interventions were investigated 1) Ipsilateral tibial nerve (iTN) stimulation at motor threshold (MT), 30–40% of the maximal peak-to-peak M-wave (M-max) and 80–90% M-max at 60%, 70%, 80%, 90% and 100% of the gait cycle of the ipsilateral leg 2) Ipsilateral sural nerve (SuN) and medial plantar nerve (MpN) stimulation at 1 ×, 2 × and 3 × perceptual threshold. For the short latency responses, the root mean squared (RMS) of the soleus EMG, contralateral to the iTN, 40–50ms post iTN stimulation was recorded. The RMS of the contralateral leg soleus (cSOL) EMG, in the steps in which stimulation occurred (30 recordings per stimulation intensity), were compared to and expressed as a percentage of the steps in which no iTN stimulation occurred (30 recordings).
RESULTS: At 80–90% M-max short latency inhibitory responses in cSOL EMG were observed in 11/14 subjects at 90% of the gait cycle ($P < .001$). No consistent responses were observed when stimulation occurred at other times of the gait cycle. Stimulation of the MpN and SuN at all stimulation intensities revealed a significant difference to the 80–90% M-max condition at 90% of the gait cycle (one-way analysis of variance: $P = .0004$; post-hoc tests $P < .05$–$P < .001$) indicating that these afferents do not contribute to the observed inhibitory response.
CONCLUSION: This was the first study to demonstrate short latency spinally mediated responses in the cSOL EMG during walking, following iTN stimulation. The response was influenced by the phase of the gait cycle and electrical stimulation intensity. In addition, the short latency response was not observed following stimulation to the MpN (muscular and cutaneous afferents) and SuN (cutaneous afferents) and indicates that muscular and not cutaneous afferents contribute to the crossed response.

CONTROL OF A 2-DOF PROSTHETIC HAND USING INTRAMUSCULAR EMG

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AIM: This study aims to demonstrate online control of a two degree-of-freedom (DoF) prosthetic hand based on features extracted from intramuscular electromyography (iEMG).
METHODS: Two able-bodied subjects took part in this study. The iEMG signals were recorded using two pairs of percutaneous intramuscular electrodes made of Teflon® insulated stainless steel wires. One pair was placed in the wrist extensors and the second pair in the flexors. Signals from this set of electrodes were used to derive hand opening and closing or wrist supination and pronation. The recorded signals were amplified, band-pass filtered (500 Hz - 5 kHz) and sampled at 10 kHz. The digitized signals were sent to a custom made LabView software program for online filtering, feature extraction, and control. In the present online study, two features were used to derive two channels of control to drive a 2 DoF prosthetic hand. The features were determined by off-line analysis of the data recorded from 10 able-bodied subjects, where the root mean square (RMS) and the global discharge rate (GDR) linearly predicted grasping force (up to 50 N). In the online system, the segmentation window had duration of 200 ms and one feature only (either RMS or GDR) was extracted. The computed values of the selected feature were sent to the hand controller after digital to analog conversion (Figure 1).
RESULTS: Online control proved possible and subjects reported no noticeable delay between their movement and the reaction of the prosthesis. However they also reported that the control was more intuitive when using RMS compared to GDR.
CONCLUSION: This study demonstrated the feasibility of using RMS or GDR as features extracted from the iEMG in online control of prosthesis. The fact that RMS feature resulted in a more intuitive control is in agreement with the prediction study which showed better performance when using RMS compared to GDR (P = 008) in terms of correlation between predicted and measured force.

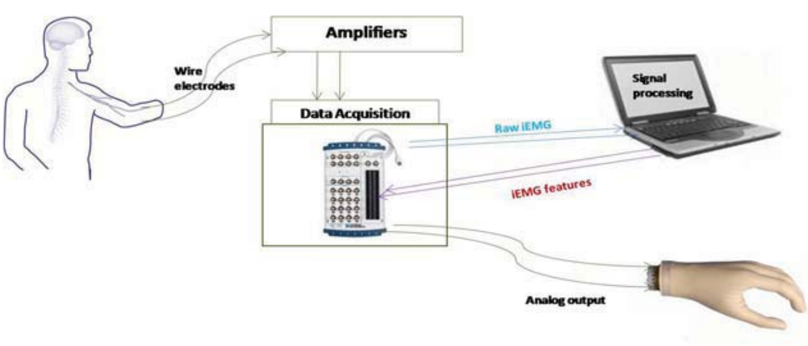

Figure 1: Setup of the online control system.

MOTOR AND ELECTROPHYSIOLOGICAL TESTS EVALUATING UPPER-EXTREMITY TELE-REHABILITATION.

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AIM: Chronic tetraplegic people participated in a randomized controlled trial (clinicaltrials.gov: NCT00656149) involving in-home, tele-supervised, FES-assisted exercise therapy (IHT-FES-ET) on a novel workstation, the ReJoyce (Rehabilitation Joystick for Computer Exercise). The ReJoyce comprises a segmented arm that presents the user with a variety of spring-loaded manipulanda, each of which is instrumented with one or more sensors, whose signals are fed to a computer to control computer games and to run the ReJoyce Automated Hand Function Test (RAHFT).
METHODS: Two treatments were compared, each tele-supervised 1 hr/day, 5 days/week for 6 weeks. Treatment 1 involved IHT-ET with conventional equipment including a weighted bracelet, a rubber web (Powerweb), a trackball and laptop with commercial computer games and a physiotherapy stimulator. Treatment 2 involved IHT-FES-ET with the ReJoyce. In this treatment, one to three muscle groups were stimulated with an FES garment the subjects triggered with small toothclicks detected by a wireless sensor like a hearing aid. FES was used to selectively augment tenodesis grasp and release. Participants were block-randomized into two groups, group 1 receiving Treatment 1 first, followed by a 1 month washout period and then Treatment 2. The second group received the two treatments in reverse order, also with an intervening 1 month washout period. All treatment sessions were performed by the participants at home with remote tele-supervision, except for 3 sessions performed in the laboratory at the University of Alberta at the end of weeks 2, 4 and 6 in each treatment. In these sessions participants took part in a battery of functional, electrophysiological and sensory tests. The primary outcome measure was the Action Research Arm Test (ARAT). Secondary outcome measures included grasp force and the ReJoyce automated hand function test (RAHFT).
RESULTS: The mean improvements in ARAT scores were 4.2% ± 9.7% after Treatment 1 and 13.0% ± 9.8% after Treatment 2. This surpassed the minimal clinically important difference (MCID) of 10%. The results showed that hand function improved in both groups, surpassing the MCID after Treatment 2.
CONCLUSION: We conclude that ET supervised over the Internet is not only feasible but also beneficial: voluntary, unassisted hand function improved after both treatments. The improvements after Treatment 2 exceeded the MCID, which is often used as one of the criteria to introduce a treatment into best practice. The RAHFT provides an automated means of quantifying outcomes. The RAHFT scores agreed well with those of accepted qualitative tests. To our knowledge the ReJoyce system is the first exercise device to enable in-home tele-rehabilitation of hand function. Independent research groups in Canada, USA, Australia and New Zealand have acquired systems and have initiated trials in SCI and stroke subjects.
ACKNOWLEDGMENTS: This work was supported by the International Spinal Research Trust and the Alberta Heritage Foundation for Medical Research. For updates visit www.hometelemed.com.

A COMPARISON OF EMG FLUCTUATION OF DELTOID AND PECTORALIS MAJOR MUSCLES IN BENCH PRESS

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AIM: The purpose of this study was to compare the EMG fluctuation of pectoralis major-clavicular portion (PMC) and deltoid-anterior portion (DA) muscles executions of bench press with barbell and dumbbell. Fifteen healthy employees males (MEAN ± SD: AGE=30.13±5.33 years; HEIGHT=175.33±6.07 cm; WEIGHT=69.80±12.14 kg) without previous injuries of elbow and shoulder joints, DA and PMC muscles, volunteered to participate in this study.
METHODS: Surface electromyography data (AEMG and MPF) were recorded and then calculated in PMC and DA muscles of dominant hand, during execution of bench press with barbell and dumbbell. Subjects performed 10 trials of bench press within 20 seconds. t-student was performed to compare differences between variables of study in significant level of $P \leq 0.05$.
RESULTS: Our results showed that, no significant difference existed between two execution of bench press with barbell and dumbbell over EMG fluctuation of PMC and DA muscles($P \leq 0.05$). However when EMG fluctuation of PMC and DA muscles were compared with each other, a significant difference was found ($P \leq 0.05$), but in both exercise executions the EMG activity of DA was higher than PMC.
CONCLUSION: The results of this study indicated that two execution of bench press with barbell and dumbbell are equally efficient in strengthening the PMC and DA muscles because the posture adapted for elevation with hand dumbbells is essentially the same one observed for elevation with barbell. Otherwise the EMG activity of DA was higher than PMC, because PMC showed abrupt activity to surpass the limb inertia and weight against the gravity action at the initial position but it was found similar behavior for DA in all phase of movement.
ACKNOWLEDGEMENT: We would like to thank Mr. Neshati and Mr. Jalali for the works they have done.

MOTOR RESPONSES TO EXPERIMENTAL ACHILLES TENDON PAIN

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AIM: Weight bearing ankle plantar and dorsal flexion exercises have been shown effective in the treatment of painful chronic Achilles tendinopathies. Basic information is needed of how the biomechanics and neuromuscular control of the exercise are affected by Achilles tendon pain. We aimed to determine the effects of experimental Achilles tendon pain on motor function during one-legged weight bearing ankle plantar and dorsal flexion exercises.
METHODS: In a cross-over study, with 16 healthy subjects tested on two different days separated by one week, 3-dimensional ground reaction forces, ankle joint kinematics and surface electromyography (EMG) of the lower leg muscles were recorded during one-legged full weight bearing ankle plantar (concentric) and dorsal (eccentric) flexion exercises. Measurements were done before, during and after either experimental Achilles tendon pain or a non-painful control condition. Pain was induced by intratendinous injections of hypertonic saline with isotonic saline injections as control. Joint kinematics, ground reaction force frequency contents, and average EMG amplitudes were calculated.
RESULTS: Compared to the control condition experimental Achilles tendon pain reduced the EMG activity in agonistic, synergistic, and antagonistic muscles, and increased the ground reaction force frequency content around 10 Hz, during both eccentric and concentric movement phases (see figure).
CONCLUSION: These data show that experimental Achilles tendon pain causes widespread and reduced motor responses with functional effects on the ground reaction force.

ACKNOWLEDGEMENT: The study was supported by grants from The Oak Foundation.

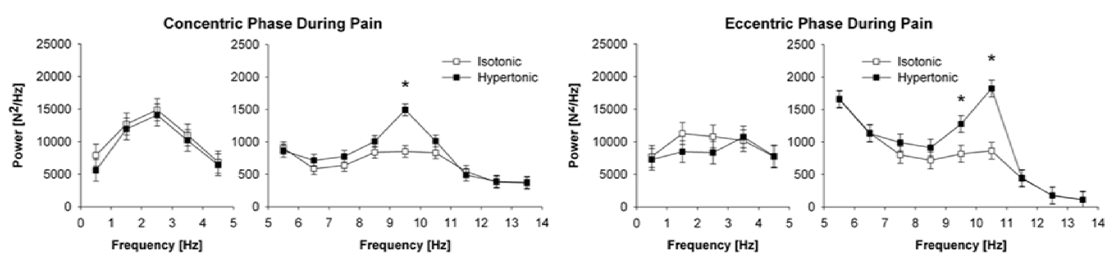

Figure 1: Group means (error bars: SE) for power spectrum densities of the resultant ground reaction force signals averaged over 1-Hz windows during the eccentric movement phase. Data represent measurements during injections of either painful hypertonic saline (filled symbols) or non-painful isotonic (open symbols) injections into the Achilles tendon. The point estimates are linked by linear interpolation lines for illustrative purposes. Asterisks denote significant differences ($P<0.0036$). Note that the y-axis scales are different below (left) and above (right) 5 Hz for visual purposes.

ELECTRO-PHYSIOLOGICAL AND PULSE WAVE VELOCITY EVALUATION IN PATIENTS OF RHEUMATOID ARTHRITIS

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AIMS: Rheumatoid arthritis is a chronic systemic inflammatory disease of undetermined etiology involving synovial membranes and articular structures of multiple joints. The disease is progressive and results in pain, stiffness and swelling of joints, also associated with carditis, pleuritis, hepatitis and vasculitis. Pulse wave velocity is an index of arterial stiffness and a marker of cardio-vascular events. The aim of this study was to investigate arterial stiffness using Carotid-Radial, Femoral-Dorsalis pedis PWV measurements and electro-physiological tests for peripheral nervous system involvement.

METHODS: 25 patients (aged between 20-60 years) with rheumatoid arthritis according to the criteria of American College of Rheumatology and 25 control subjects of the same and sex were recruited. The pulse wave velocity was recorded with the help of Polywrite-4 channel machine and electro-physiological tests were recorded using RMS EMG EP mark II.

RESULTS: Distal neuropathy was dominant; statistically significant decrease in conduction velocity, latency and decreased amplitude of tibial nerve was seen as compared to median nerve in the upper limb. The most frequent abnormality was decrease in sensory nerve conduction velocity both in median and sural nerves. The carotid, radial, femoral-dorsalis pedis pulse wave velocity was statistically significantly higher in rheumatoid patients as compared to control patients.

CONCLUSION: Electro-physiological findings of peripheral nerve damage even in the absence of clinical evidences are common in rheumatoid arthritis. Measurement of carotid-radial, femoral-dorsalis pedis may provide simple and non-invasive technique for identifying patients at increased risk of vascular disease.

ELECTRODIAGNOSTIC STUDIES FOR EARLY DIAGNOSIS OF GUILLAIN BARRE SYNDROME IN INDIAN PATIENTS

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AIMS: Guillain Barre Syndrome (GBS) is an acute immune mediated de-mylelinating poly-radiculo-neuropathy which manifests as progressive, symmetrical ascending muscle weakness, areflexia with or without sensory, autonomic and brainstem abnormalities.

METHODS: The present study was carried out in the Deptt. of Physiology, Pt. B.D. Sharma PGIMS, Rohtak, for early confirmation of clinically diagnosed patients of Guillain Barre syndrome by electro-physiological tests which included motor conduction studies in median, ulnar, tibial & peroneal nerves & F wave studies which includes F wave conduction velocity and F wave latency in 50 subjects (25 were clinically diagnosed patients of Guillain Barre Syndrome, 25 as control group) using RMS EMG EP Mark II. F wave is the late response resulting from antidromic activation of motor neurons involving conduction to and from the spinal cord.

RESULTS: Statistically significant slowing ($P<0.001$) of motor conduction velocities, F wave conduction velocities, decreased amplitude as well as increased distal motor latencies of median, ulnar, tibial and peroneal nerves was seen in the GBS group as compared to control group, slowing of conduction velocities as well as increase in distal motor latencies being more pronounced in lower limbs. The lower limb is affected more as it is causes ascending muscle paralysis. Out of 25 subjects of GBS group, F wave conduction velocity was absent in 80 %, 68%, 20% and 12 % in peroneal, tibial, ulnar and median nerves respectively.

CONCLUSION: Electro-physiological studies play an important role in the early detection, characterization & treatment plan of inflammatory demyelinating poly-radiculopathies because timely intervention reduces morbidity and disability. This study also highlights that F-wave is most sensitive for early diagnosis of Guillain Barre Syndrome.

HYPOSTHENIA OF THE ABDOMEN TRANSVERSE MUSCLE AS A POSSIBLE CAUSE OF MECHANICAL RACHIS PATHOLOGIES

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AIM: The objective of the study is to prove the correlation between hyposthenia of the abdomen transverse muscle and pathologies related to mechanical overload of the rachis.
METHODS: In the period between September 2002 and December 2008 inclusive, 333 subjects (163 males and 170 females born between the years 1950 and 1969) were subjected to neurosurgical examination and kinesiological assessment. The diagnosed pathologies ranged from anterolisthesis to lumbar stenosis. Patients who had previously undergone surgery on the rachis were excluded from the study. No other exclusion criteria were adopted. In people affected by lumbalgia, the radiological examinations (Rx and MR) did not show deterioration of the disc or other evident signs of ongoing rachis pathologies. The collected data were divided according to age decade in order to verify if there were substantial differences between the two groups.
RESULTS: In the re-athletization phase, subjects that only perform exercises for the rectum and the abdomen oblique muscles and not for the transverse muscle do not experience important symptomatic improvements as those who instead also perform the latter. The average calculated BMI varies between 23.32 and 25.56. In both groups, the percentage of subjects with an hyposthenic transverse muscle (obese abdomen) exceeds 90%, whereas the most common pathology is the bilateral lumbalgia followed by L5-S1 discopathy. From the collected data it results that the majority of subjects who suffer from pathologies caused by mechanical overload of the rachis have hyposthenia of the abdominal muscles, particularly the abdomen transverse muscle, and an average BMI that exceeds the normal threshold. Therefore, it could be stated that a direct relationship exists between abdominal hyposthenia, overweight and pathologies caused by mechanical overload of the rachis. But, as is often observed, there are many subjects who are overweight and exhibit abdominal hyposthenia yet do not show rachis anomalies or related symptoms. Thus, abdominal hyposthenia can be considered as one, but not the only, cause of possible rachis pathologies due to mechanical overload.
CONCLUSION: When the subjects included in the study were assessed they already showed signs and symptoms of the diverse pathologies. For clearer understanding of the role that the abdominal muscles and particularly the abdomen transverse muscle play within rachis biomechanics, it is necessary to study a healthy population that does not exhibit clinical symptoms or signs and that has radiological examinations within the norm. This could probably answer the questions: Does the abdomen relax because there is a problem at the rachis? Is there a problem at the rachis because the abdomen has relaxed? If the abdomen relaxes, will we have a problem at the rachis?

LUMBAR STENOSIS AND PELVIC TILT AS POSSIBLE CAUSES OF AN INCREASING INCIDENCE OF COXARTROSIS, A RETROSPECTIVE STUDY

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AIM: The study is aimed at demonstrating a close connection between lumbar stenosis and pelvic antiversion resulting in an increasing incidence of coxartrosis.
METHODS: 41 patients suffering from lumbar stenosis (17 women and 24 men aged between 46 and 79; 21 of whom have undergone surgery for lumbar stenosis) underwent postural evaluation and radiological screening.
RESULTS: The evaluation of rachis showed a decrease in the lordotic curve in the lumbar region for 38% of non-operated subjects and 45% of operated subjects. 50% of the subjects presented a retraction of the ischiocrural muscle group. The gluteus major has shown to be the weakest muscle in 24,4% of the cases. The radiological screening showed that 73,7% of operated subjects had pelvic retroversion while 10,52% had pelvic antiversion. 42,8% of non-operated subjects presented pelvic retroversion while 4,7% showed pelvic antiversion. 89,5% of operated subjects and 71,4% of non-operated subjects showed modest to significant coxartrosis.
CONCLUSION: The data partially confute the starting assumption since pelvic retroversion (57,5%) and hypolordosis have been found as opposed to pelvic antiversion (7,5%) and hyperlordosis. The radiological screening of coxofemoral joint (coxartrosis: 80,5%) seemed to confirm the starting assumption. The conflicting data could find an explanation in the following hypotesis, holding that the courseof lumbar stenosis may cover two phases:
a) step 1: a development phase, where hyperlordosis, pelvic antiversion and the initial stage of coxartrosis may be found
b) step 2: a gradual decrease in lumbar hyperlordosis, which could correspond to antalgic postureand increasing coxartrosis.
Further studies will be necessary to confirm the starting assumption and understand the evolution of the pathology connected to pelvic tilt.

EMG PATTERN RECOGNITION ADAPTATION

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AIM: Adaptation algorithms for EMG pattern recognition based control of powered upper limb prostheses were investigated. The goal was to prevent performance degradation due to EMG pattern changes that can be caused by daily use, such as electrode shift and muscle fatigue.

METHODS: An assessment protocol was developed to evaluate the pattern recognition system's performance in real-time, while electrode shift or muscle fatigue was induced. Performance was assessed by the rate of completion of a dynamic real-time test. This protocol enabled the characterization of each confounding factors' effect upon EMG patterns, the assessment of the system's and user's ability to adapt to pattern changes, and the evaluation of a novel adaptation scheme to accommodate changes in EMG patterns. The adaptation algorithm shifts the parameters of a Bayesian classifier (class mean and covariance) as changes occur.

RESULTS: As expected, with no adaptation (NA) electrode shift produced significant performance degradation; much more so than muscle fatigue and no inducement, as shown in Figure 1. Batch adaptation (BA) is equivalent to retraining the prosthesis by generating a completely new training set if a systemic change in EMG is suspected. Although this approach is the most effective at preserving classifier accuracy, it is not convenient for the user, especially for transient phenomena such as fatigue. It can be seen that supervised adaptation (SA) performs as well as BA in each case. SA is similar to conducting a series of motions that are pre-determined while the classifier retrains online, gradually adapting its parameters to new data. This method is the best performing method when retraining online, but the most practical adapts while unsupervised (UA), meaning that it is not necessary to conduct a series of pre-determined motions. UA did not perform as well as BA or SA with shift or fatigue induced, but allowed much better performance than NA.

CONCLUSION: Implementing the novel adaptation algorithm into pattern recognition myoelectric prostheses system does prevent real-time performance from decreasing over time. However, a more robust method of selecting classes' mean and covariance shifting gradients while class membership is unknown needs to be developed to improve unsupervised adaptation.

ACKNOWLEDGEMENT: The Natural Sciences and Engineering Research Council of Canada and the New Brunswick Innovation Foundation.

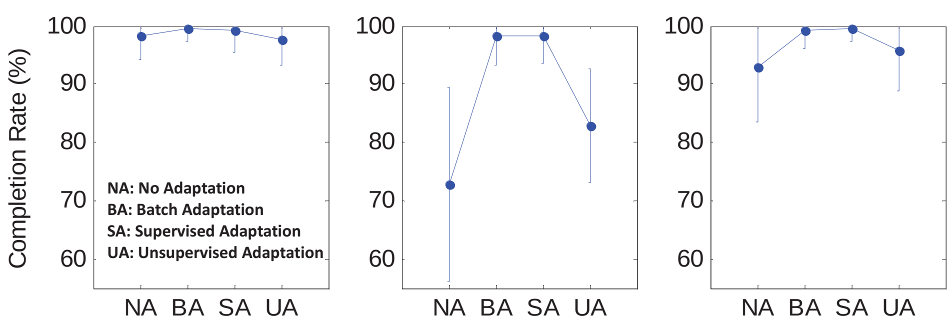

Figure 1: Real-time completion rate's mean and standard deviation across 7 subjects.

ATLAS OF MUSCLE INNERVATION ZONES FOR PROPER SEMG ELECTRODE PLACEMENT: PRELIMINARY RESULTS

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AIM: The issue of electrode placement is crucial to obtain accurate estimates of the SEMG signal variables. Recommendations remark that SEMG electrodes should be placed between the innervation zone and the tendon. Nevertheless, information about innervation zone locations for relevant skeletal muscles are not yet available. The purpose of this study is to describe innervation zone locations in skeletal muscles and therefore to provide details for ensuring a proper positioning of bipolar electrodes. We will present results from a first set of muscles.
METHODS: Forty healthy subjects (20 males and 20 females) aged between 20 and 30 years has been enrolled after giving a written consent. Innervation zone has been investigated during submaximal isometric contractions using a linear array of electrodes, with 5 mm interelectrode distance, applied on standard anatomical landmark frames.
Surface EMG signals were recorded from 12 muscles: Rhomboideus Major, Rhomboideus Minor, Middle Trapezius, Lower Trapezius, Pectoralis Major, Posterior Deltoid, Lateral Deltoid, Anterior Deltoid, Triceps caput longum, Triceps caput laterale, Biceps Brachii caput breve, Biceps Brachii caput longum.
RESULTS: All the investigated muscles showed a well-defined innvervation zone that in most cases was found not wider than the interelectrode distance (5 mm). High intersubject uniformity for the innervation zone location has been observed for the muscles investigated except for Rhomboideus Major and Rhomboideus Minor. In few cases Biceps Brachii showed a double innervation zone.
CONCLUSION: Optimal electrode sites have been identified for all the investigated muscles. Information for a proper electrodes placement on the basis of anatomical landmarks were thus provided. The same information may be useful for optimization of botulinum toxin injection.

BALANCE TRAINING WITH NINTENDO WII FIT - A PARALLEL RCT-STUDY

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AIM: The fall incident is 30 % amongst elderly community dwellers aged 65 year and older. Fall is a frequent reason to reduce the level of function, and causes both the individual and the public society, large expenses. One of the largest risk factors in relation to fall is balance deficit. Balance training is an important part of a multifactorial intervention to prevent falls. Nintendo Wii Fit could be a new way to improve the balance, but there is still a need for further studies, to examine its effect. The aim of our project is to measure the outcome effect of balance training with Nintendo Wii Fit as a physiotherapeutic balance instrument for elderly community dwellers.
METHODS: We have used a quantitative parallel RCT-study, where the participants are block randomized into 2 groups by gender. 20 participants were included, 11 men and 9 women, at the age of 71-89. The exercise group (n = 10) participates in training sessions with Nintendo Wii Fit 20 min. 2 times/week for 4 weeks. Outcome measurements are Metitur force platform static and dynamic tests, mCTSIB, FES-I and TUG.
RESULTS: The exercise group showed statistic significant improvement in 4 out of 69 parameters. The parameters are: Score (p = 0,043) and Mean Y-speed (p = 0,012) in Metitur static, normal EO, and time in Metitur dynamic test (p = 0,043), and the total score in mCTSIB (p = 0,012). It is estimated that the sample size has a large influence on the results.
CONCLUSION: In the light of our results, it is not possible to prove a statistic significant improvement of the balance in elderly community dwellers after intervention with Nintendo Wii Fit. We cannot determine if Nintendo Wii Fit can be used as a physiotherapeutic instrument for balance training in elderly community dwellers. There is a need of further research with a larger sample size to estimate the effect of Nintendo Wii Fit as an instrument for balance training in elderly community dwellers.
ACKNOWLEDGEMENT: A thank to University College of Northern Jutland for assistance during the project.

MARKERLESS VIDEO ANALYSIS PROTOCOL TO EVALUATE THE BIOMECHANIC EFFECTIVENESS OF THE SNATCH

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AIMS: This work investigates the biomechanics of the barbell trajectory in the Olympic Weightlifting, and aims to: 1) probe the effectiveness during the athletic task and, 2) offer an innovative technique of video analysis to simplify the study of center of gyration of the barbell-athlete system (BAS).
METHODS: During the 2008 Italian FIPCF Weightlifting Championship, 159 "snatch" technical performances executed by 64 male athletes were videotaped. The used video analysis procedure, identified the "silhouette", a frame region which represent the distribution of BAS masses on the sagittal plane during the weightlifting performance (Figure 1). Three characteristics were extracted from that shape: 1) a centroid used to represent an homographic projection of center of gyration (PCG) of the BAS; 2) the linear fitting coefficient (R^2) of the regression line of PCG horizontal component, used to value the verticalization of PCG trajectory; 3) the magnitude of the principal interaxes angle of the silhouette (MAS), used to represent the displacement of BAS masses in the frame plane and to identify the technical phases of the snatch. Time and frequency analyses of PCG coordinates and MAS amplitude were executed to search for differences among eight groups of lifts. These groups were generated from the 159 snatch, through the combination of effectiveness presence/absence and barbell path typology (elongated S, BEST and maximum verticalization, WORST, Figure 2).
RESULTS: Statistically significant differences among effectiveness and no effectiveness groups of lifts (Dunn-Sidak Post Hoc nonparametric test, after bootsrapping) were found in power spectrum analysis of both WORST PCG plane component (ES_{YPCG} = 4%, ES_{XPCG} = 3%, $p<0,05$), BEST PCG vertical component (ES_{YPCG}=17%, $p<0,05$), and in time domain horizontal displacement of WORST PCG (ES_{XPCG} = 22%, $p<0,05$).
CONCLUSIONS: It was possible to demonstrate that there is a link between mechanical efficiency of lifting and: 1) power spectrum of the PCG coordinates and MAS magnitude variation; 2) bodyweight and lifting strategy: athletes with greater muscular masses and strength, were able to use the stretched S technique, whereas athletes with greater kinesthetic control ability, adopted a more verticalized barbell trajectory.
ACKNOWLEDGEMENTS: We wish to thank the Italian Weightlifting Federation (FIPCF). This work was part of a PhD programme funded by Fondazione ISEF, Turin, Italy.

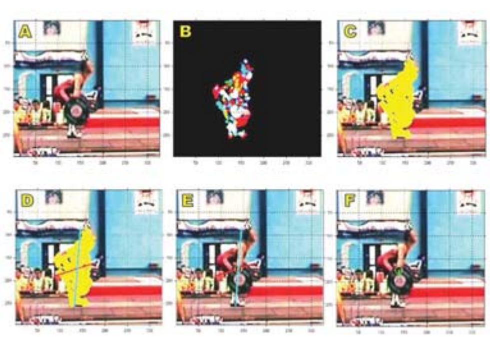

Figure 1: Video Analysis Procedure to identify in a Frame (A) the silhouette (B – C – D), the principal axes of the silhouette (D – E) and the PGC (F).

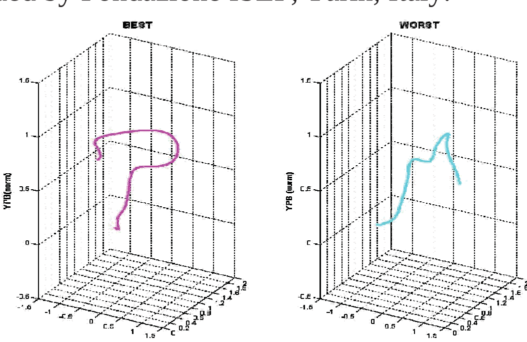

Figure 2: the canonical elongated S snatch tecnique (BEST) and the maximum verticalization of barbell trajectory (WORST).

ESTIMATION OF MUSCLE FIBER DIRECTION BY MATRIX ELECTRODE

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AIM: We can measure Surface electromyogram (SEMG) only by pasting an electrode on skin. However, we must pay very careful attention to paste an electrode on skin. For example, we must consider about muscle fiber direction (MFD). Therefore an aim of this study is development of the SEMG measurement procedure that can calculate the SEMG which considered in a MFD by data processing after measurement, even if we paste an electrode on skin without considering in a MFD. We suggest procedure to estimate a MFD using SEMG data after measurement in this study.

METHODS: In our procedure, we record differential signal of matrix electrode and reference electrode. By calculating a differential signal of two any recorded signal, we can get the signal similar to bipolar lead signal between any two electrodes. We show below the method. We assume a MFD and an electrode direction like a figure.1. A MFD expresses with a full line arrow and an electrode direction expresses with a broken line arrow. At first we assume a differential signal between electrode E-F α, E-B β, and E-C γ. Also we assume a gap of conduction distance of α and β $d_{1,}$ and β and γ d_2.From two right-angled triangles which have line segment BC and FB on the oblique side, we get formula (1) and (2). And we calculate t_1 and t_2 which is time lag of cross-correlation function of α and β and of β and γ. When we suppose that muscle fiber conduction velocity of the same motor unit is same (=ν), we get formula (3) and (4). We get formula (5) from four above-mentioned formulas.

$$\sin\theta = \frac{d_1}{d} \;\; (1),\quad \cos\theta = \frac{d_2}{d} \;\; (2),\quad d_1 = \upsilon \cdot t_1 \;\; (3),\quad d_2 = \upsilon \cdot t_2 \;\; (4),\quad \theta = \tan^{-1}\frac{t_1}{t_2} \;\; (5)$$

We experimented to confirm usability of our procedure. We made the matrix electrode which had 16 electrodes (4×4). At first we made sure of a MFD of subject (both of long head and short head of biceps brachii muscle) using ultrasound imaging device before an experiment. We fixed a matrix electrode to fall on for both head of biceps brachii muscle.

RESULTS: By our procedure, we got θ =22.4 degrees. The angle between long head of biceps brachii muscle and short head of biceps brachii muscle was 22 degrees.

CONCLUSION: In this study we experiment only about 22 degrees that we made sure of. However, the angle which we calculated by our procedure was 22.4 degrees. Therefore, if we use our procedure, we think that we can estimate a MFD using SEMG after measurement. And we can also choose two electrodes which along a MFD from a matrix electrode.

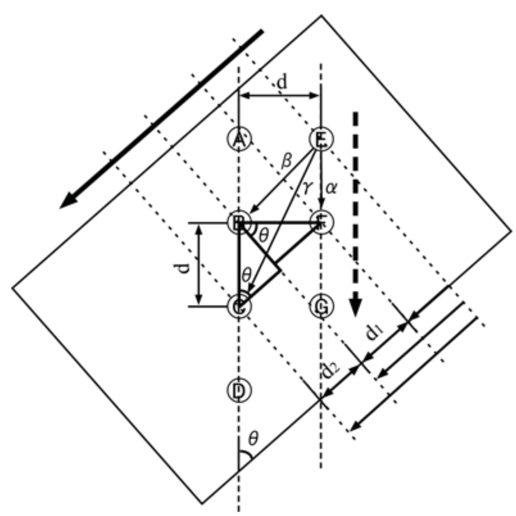

Figure 1: Pattern diagrams of a MFD and an electrode direction.

EFFECTS OF DIFFERENT PEDALING RATES ON MUSCLE ACTIVITY OF LOWER EXTREMITY AND CRANK TORQUE DURING CONSTANT WORK RATE PEDALING

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AIM: There is diversity in the combination of the loading and the pedaling rate when the constant work rate pedaling. So that combination pattern is infinity. As a result, it changes the joint torque, the muscle activity, and the energy consumption, etc. The study of the pedaling rate with high energy efficiency is admitted when the pedaling is operated at the high constant work rate; however the study at the work rate used by rehabilitation is few though. Moreover, it is possible to change the number of replications within the fixed time if the pedaling rate changes, which influence the amount of a muscle activity. The purpose of this study was that the influence given to the characteristic of the amount of a muscle activity within the fixed time and the muscle activity efficiency of one-rotation inside was clarified from the average muscle activity and the maximum muscle activity on the lower extremity muscle when the pedaling rate was changed during constant work rate pedaling.
METHODS: Ten subjects participated in the study. Using active electrodes, the electromyographic activity during ergometric cycling was measured from the rectus femoris, vastus medialis, semitendinosus, gastrocnemius medialis, and tibialis anterior. Crank torque during ergometric cycling was measured by two strain gauges and two dummy gauges. We measured crank rotation and hip, knee and ankle angle on pedaling by Vicon system. Ergometric cycling was performed under five pedaling rates (40, 60, and 80,100,120rpm) into two work rates (60W, 120W). After recorded electromyography for 12 seconds or more, we used into six seconds. That is, 12 rotations in 120 rpm, by ten rotations in 100 rpm, by eight rotations in 80 rpm, by six rotations in 60 rpm, by four rotations in 40 rpm. About the average muscle activity, the electromyography was the root mean square of electromyography was calculated. Moreover, the peak muscle activity was detected by the maximum value in one cycle and calculated the mean value for five cycles. After that, all electromyography signals were normalized by the maximum voluntary contraction.
RESULTS: Rectus femoris was not changing average muscle activity between 40 to 80 rpm in 60W and 120W. But it increased over 100 rpm in 60W and 120W. Peak muscle activity was most decreased at 60 rpm in 60W and 120W. Vastus medialis was not changing both average and peak muscle activity between 40 to 80 rpm in 60W and 120W. But it increased over 100 rpm in 60W. Both average and peak muscle activity was most decreased at 60 rpm in 120W.Semitendinosus was not changing both average and peak muscle activity between 40 to 100 rpm. It was most increased at 120 rpm. Gastrocnemius medialis was increased both average and peak muscle activity with an increase in the rotational speed. Crank torque was most decreased at 60 rpm and most increased at 120 rpm in 60W. It was most decreased at 80 rpm and most increased at 120 rpm in 120W.
CONCLUSION: The muscle activity was able to be increased intentionally by using the pedaling rate with a high each muscle, and the quadriceps was thought that 60 rpm of the muscle activity lowered.

EFFECTS OF BACK MUSCLE FATIGUE ON EQUILIBRIUM ABILITY

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AIM: It is known that patients with lower back pain (LBP) suffer from tightness and fatigue in the lumbar and abdominal muscles. Abdominal stability increases equilibrium function. Additionally, patients with LBP suffer from muscle fatigue. This is believed to reduce equilibrium function, and there have been some reports of relationships between muscles in the abdominal region and equilibrium function. This study investigates lumbar muscle fatigue and equilibrium function.

METHODS: Subjects were 11 healthy male adults (mean age 20.0±0.7 years) with no history of neurological or orthopedic disease. The subjects were enrolled after obtaining written informed consent. Postural balance was measured with a Gravicorder GS-31P stabilometer (Anima Co.) in two trials of 30s each, under conditions of static upright posture with eyes open. Data sampling frequency was 20Hz. Before fatigue, equilibrium ability was used to measure static and dynamic balance. The method of fatigue employed (Sorensen method) has been used many times previously to measure back muscle endurance. Subjects who stated that they were physically fit and able to perform the exercise for long periods of time were given the option of holding a weight in each hand (3.0kg) with their arms placed up by their chest. After the first exhausting exertion, subjects were given 30s rest and repeated the trunk extension trial 6 times to exhaustion. After fatigue, equilibrium ability was measured again. Pre- and post-fatigue differences were examined with the paired T-test using SPSS ver15. Differences with $p<.05$ were considered significant

RESULTS: Subjects with post-fatigue and with eyes open showed poorer standing balance ability (LNG;LNG/TIME;LNG/ENV・A;REC・A; RMS;RMS・A;ENV・A;REC・A).[Table1]

CONCLUSION: Static equilibrium ability was found to decline significantly with lumbar muscle fatigue, indicating that fatigue in the center of the trunk caused difficulty in controlling the center of gravity. This is believed to reflect a feature of lumbar fatigue of patients with LBP, and further research into functions of the torso in patients with LBP is desirable.

Table 1: pre- and post-fatigue equilibrium ability evaluation (static).

	Pre-fatigue	**Post-fatigue**	
LNG（cm）	35.6±9.0	53.1±8.4	＊＊
LNG/TIME（cm/sec）	1.2±0.3	1.8±0.3	＊＊
LNG/ENV・A（cm^2）	29.2±12.7	14.8±6.9	＊＊
RMS（cm）	0.58±0.24	0.99±0.33	＊＊
RMS・A（cm^2）	1.2±1.1	3.4±2.2	＊
REC・A（cm^2）	4.0±2.8	12.1±7.4	＊＊
ENV・A（cm^2）	1.5±0.9	4.4±2.3	＊＊

＊$p<.05$、＊＊$p<.01$

INFLUENCE OF DYNAMIC BALANCE ON LUMBAR MUSCLE FATIGUE

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AIM: The purpose of this study was to clarify the influence of postural control on lumbar muscle fatigue.
METHODS: Subjects were 8 healthy young people, ranging in age from 19 to 21 years. We initially conducted a dynamic balance test using the EquiTest system (NEUROCOM, Clackamas, USA), followed by an evaluation of conditions 3, 4, and 6 of the Sensory Organization Test. Condition 3 involves the stimulation of vision by a moving wall in front of the subject, condition 4 involves the subject standing on a swinging floor, and condition 6 combines the contents of conditions 3 and 4. The method for inducing fatigue in this study has been used previously to measure back muscle endurance (Sorensen method). After the first exhausting exertion, subjects were provided a 30s rest period, followed by a trunk extension trial which was repeated 6 times until exhaustion was reached. Following the induction of fatigue, dynamic balance ability was measured again. Pre- and Post-fatigue differences were examined with the paired Wilcoxon signed-rank test using SPSS ver15. $P < .05$ was considered significant.
RESULTS: A significant difference in root-mean-square (RMS) sway with condition 6 was seen when pre- and post-fatigue dynamic balance were compared (Table 1).
CONCLUSION: These findings suggest that stimulation of sight or somatic sensation alone did not result in a difference in RMS sway; stimulation of both factors was needed to elicit a change in RMS sway. We conclude that trunk balance becomes unstable due to muscle fatigue when both sight and somatic sensation are stimulated, thereby influencing postural control.

Table 1: Comparison of Equitest data sway paths in elderly pre- and post-fatigue. *p<0.05

	Cond3		Cond4		Cond6	
	Pre	Post	Pre	Post	Pre	Post
RMS(cm)	12.21±7.40	20.13±10.15	93.24±34.78	93.89±16.09	25.25±15.89*	53.55±28.61*
LNG（cm）	4.14±3.19	5.07±3.02	56.87±13.95	60.44±9.79	23.90±19.53	44.60±38.13
REC・A（cm^2）	2.49±1.95	3.69±1.72	46.19±14.84	52.78±6.95	18.26±15.63	26.33±21.95

VISUAL FEEDBACK BALANCE TRAINING IMPROVES POSTURAL STABILITY AFTER VESTIBULAR SCHWANNOMA SURGERY

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AIM: To prove effectiveness of balance training using visual feedback, in patiens undergoing microsurgical removal of vestibular schwannoma. Postural stability was measured by means of posturography.
METHODS: 12 patients allocated into two groups: feedback group (6 patients, mean age 32 years) and standard physiotherapy group (6 patients, mean age 41 years). Patients in both groups were treated once per day by intensive rehabilitation from 5th to 14th postoperative day. Posturography (Clinical Test for Sensory Interaction of Balance) was used to quantify the effect of training with feedback on postural satbility. Body sway was evaluated from centre of foot pressure.
RESULTS: We evaluated four CoP parameters in the course of postoperative training. We compared data of standard rehabilitation group with visual feedback based training. Significant differences of the studied parameters were observed after 2-week balance training. Patients in the group of visual feedback–based training program demonstrated significant difference in amplitude of CoP in medio-lateral direction ($p = 0.032$), line integral ($p = 0.025$) and total area ($p = 0.016$).
CONCLUSION: Results of this clinical study suggest that visual feedback–based balance training speeds vestibulo-spinal compensation after tumor removal surgery.
ACKNOWLEDGMENT: This study was supported by the research project MSM 6840770012.

ELECTRODE CONFIGURATION FOR MULTIFUNCTIONAL MYOPROSTHESES

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AIM: Assessing the effect of strategies for electrode positioning on classification accuracy of high-dimensional surface myoelectric signals (sEMG) for hand movements.
METHODS: With a matrix electrode array located around the forearm, 126 monopolar sEMG signals where recorded from three able bodied subjects performing repeatedly six different static contractions (hand open/close, wrist flexion/extension/abduction/adduction). After longitudinal bipolar derivation (inter-electrode distance 16 mm) yielding 74 signals, six bipolar signals where selected and Fisher linear discriminant analysis (LDA) was used to classify their relative root mean squares (RMS). The mean classification accuracy of this six-class problem was compared for three electrode selection methods: 1) Six equally spaced electrodes on a circle around the forearm as used in many publications in this field. 2) The positions where chosen to be in the six spatial RMS maxima of the contractions. This corresponds to the method how an orthopaedic technician would choose electrode positions when fitting a myoprosthesis. 3) Six electrodes where automatically selected by sequential floating forward selection (SFFS) by directly optimizing the classification performance. To avoid overfitting, classification results were generated by nested crossvalidation.
RESULTS: The equally spaced selection and the spatial maxima configuration led to mean classification accuracies around 90 %. SFFS yielded a mean classification rate above 97 %.

Subject	**1**	**2**	**3**	**Mean**
Equal Spaced	88.52 ± 8.43	94.15 ± 6.37	96.02 ±4.10	92.89 ± 6.30
Spatial Maxima	87.45 ± 4.31	90.65 ± 15.78	88.05 ±10.24	88.72 ± 10.11
SFFS	98.83 ± 1.96	95.85 ± 6.63	97.32 ±3.39	97.33 ± 3.99

Table 1: Classification accuracies in percent for different electrode selection methods

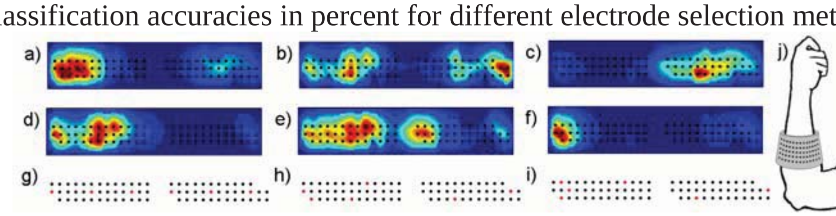

Figure 1: a-f: Typical spatial RMS patterns, upper edge proximal (a: hand open, b: hand close, c: wrist flexion, d: wrist extension, e: wrist abduction f: wrist adduction); g-i: typical derived bipolar signal selection (g: equal spaced, h: spatial maxima, i: SFFS); j: array location

CONCLUSION: These results suggest that individually optimized electrode positions significantly improve the classification performance in myoelectric control tasks even with simple features and classifiers such as rRMS and LDA. SFFS is a powerful method for this optimization process. For a prospective application in multifunctional myoelectric prostheses, high density electromyography could be used in the fitting process to determine positions for a relatively small number of electrodes that are later efficient in controlling the prosthesis.
ACKNOWLEDGEMENT: The Project was supported by the Bernstein Focus Neurotechnology, grant “01GQ0811”. We would like to thank Walter Paulus, Clinical Neurophysiology, University Göttingen for providing us with a Biosignal amplifier for this study.

MUSCULAR ACTIVATION DURING REVERSE AND NON-REVERSE CHEWING CYCLES IN UNILATERAL POSTERIOR CROSSBITE.

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AIM: The aim of this study was to characterize the kinematics and masseter muscle activation in unilateral posterior crossbite.
METHODS: Eighty-two children (8.6 +/- 1.3 yr of age) with unilateral posterior crossbite and 12 children (8.9 +/- 0.6 yr of age) with normal occlusion were selected for the study. Electromyography (EMG) and kinematics were concurrently recorded during mastication of a soft bolus and a hard bolus.
RESULTS: The percentage of reverse cycles in the group of patients was 59.0 +/- 33.1% (soft bolus) and 69.7 +/- 29.7% (hard bolus) when chewing on the crossbite side. When chewing on the non-affected side, the number of reverse cycles was 16.7 +/- 24.5% (soft bolus) and 16.7 +/- 22.3% (hard bolus). The reverse cycles on the crossbite side were narrower with respect to the cycles on the non-affected side. Although both types of cycles in patients resulted in lower EMG activity of the masseter of the crossbite side than of the contralateral masseter, the activity of the non-affected side was larger for reverse than for non-reverse cycles.
CONCLUSION: It was concluded that when chewing on the crossbite side, the masseter activity is reduced on the mastication side (crossbite) and is unaltered (non-reverse cycles) or increased (reverse) on the non-affected side.

THE INTERFERENCE OF ANTAGONISTIC MUSCLE CONTRACTION TO THE MOTOR CORTEX EXCITABILITY INDUCED BY THETA BURST STIMULATION

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BACKGROUND: Theta burst stimulation (TBS) is a novel technique of repetitive transcranial magnetic stimulation. It has been shown that the effects of TBS on the motor cortex excitability would interact with voluntary activity in the target muscle.
AIM: To explore the possibility of intracortical regulation between neurons dominating pairs of antagonistic muscles.
METHODS: 6 Subjects participated in the study to receive continuous theta burst stimulation (cTBS). In a bright room the subjects were seated in a comfortable chair with their right arm fixed in a thermoplastic splint to keep the elbow rest in 90° of flexion. The subjects received contralateral TBS on the motor hot spot of right flexor carpi radialis (FCR) in three conditions: in rest, simultaneously with right extensor carpi radialis (ECR) contraction, or followed by 1-minute ECR contraction. The ECR contraction was set at 10% maximal voluntary effort. Motor evoked potential (MEP) in FCR was measured before and after the procedures of TBS and muscle contraction for twenty-five minutes to evaluate their influences on motor cortex. Two-factor repeated measured analysis of variance (ANOVA) and post-hoc analyses were applied to test the effect of ECR activity on the MEP changes in the FCR. The level of statistical significance was set at 0.05.
RESULTS: The effect of ECR contraction was not statistically significant ($F=0.03$, $p>0.05$). No significant interaction between the time post-TBS and ECR contraction was found ($F=1.23$, $p>0.05$). However, the time post-TBS contributed significant effects on FCR MEP ($F=4.29$, $p<0.05$). The post-hoc analyses revealed that the cTBS and cTBS followed by 1-minute ECR contraction suppressed the MEP of FCR up to 20 minutes, while the cTBS during ECR contraction did not alter the FCR MEP.
CONCLUSION: The effects of cTBS on the cortical excitability were interrupted by concurrent antagonistic muscle contraction, but not significantly influenced by post-TBS contraction.

THE PSOAS, NO HIP FLEXOR IN THE ACTIVE STRAIGHT LEG RAISE (ASLR)?

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AIM: To assess the psoas function during the Active Straight Leg Raise (ASLR), determine whether during hip flexion the psoas always has the same function as the iliacus, and whether the psoas affects the hip more than the lumbar spine.
METHODS: 17 healthy women (20-40 years old) performed ASLR, with the right and the left leg (“Side”), and without or with weight added above the ankle (“Weight”). Fine wire EMG was registered of the psoas and the iliacus, and surface EMG was used for activity of the rectus femoris and the adductor longus, all on the right side. Movements of the leg were registered with active markers and a camera system (OPTOTRAK).
RESULTS: During ipsilateral ASLR, all muscles studied were active, while only psoas was active during contralateral ASLR. Muscles were activated before ipsilateral movement onset, the iliacus, rectus femoris, and adductor longus largely at the same time, before the psoas. There was no significant difference between the amplitudes of ipsilateral and contralateral psoas activity, or between ipsilateral and contralateral onset times of the psoas. Nor was there a significant interaction between Side and Weight for the psoas.
CONCLUSION: During ASLR, ipsilateral psoas activity is consistent with the psoas being a hip flexor. However, contralateral activity is not and suggests that the psoas is bilaterally recruited to stabilize the lumbar spine, probably in the frontal plane.

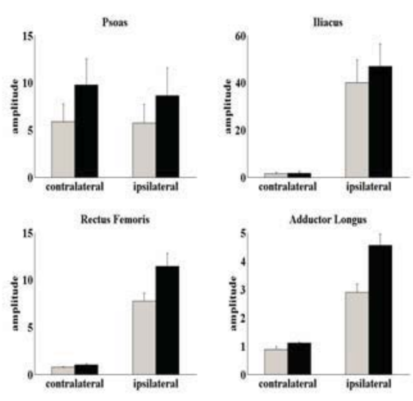

Figure 1: EMG (mV) of the psoas, iliacus, retus femoris, and adductor longus, during contralateral and ipsilateral ASLR without (grey) or with (black) weight added. Error bars represent standard deviations.

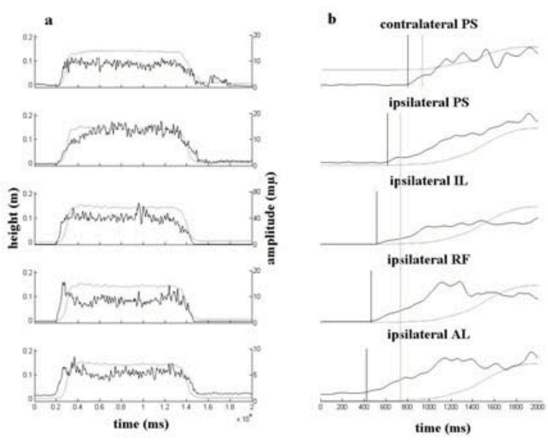

Figure 2: a. Representative example of EMG (mV, right vertical axis, black) and leg movement (m, left vertical axis, grey) during ASLR; **b**. Greater temporal resolution of the onset of EMG (black vertical lines) and leg movement (grey vertical lines).

POSTURAL-SUPRAPOSTURAL CONTROL WITH DIFFERENT TASK LOADS: BEHAVIORAL DATA AND NEURAL CORRELATES

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AIMS: By manipulating task-load of a particular dual-tasking, we investigated task interplay and underlying cortical processing for a postural-suprapostural dual-tasking with a motor suprapostural goal.
METHODS: Fourteen healthy adults conducted ongoing force-matching maneuvers (static vs. dynamic) under two stance conditions (bilateral stance (BS) vs. unilateral stance (US)); meanwhile, precision of force-matching, center of pressure dynamics, and event-related potentials (ERPs) were monitored.
RESULTS: A significant interaction effect was noted on precision of suprapostural force-matching, depending on relative task-load of the task (matching error: BS_static < US_static; BS_dynamic > US_dynamic). However, standardized postural sway in the BS conditions was affected by force-matching version (BS_static > BS_dynamic), but was significant reduced with enhanced regularity in the US conditions. ERP structures strongly suggested a task-specific cortical processing for postural-suprapostural control. N1 component was subject to stance effect with a greater amplitude around parietal cortex for both US conditions (US_static > BS_static; US_dynamic > BS_dynamic). In contrast, P2 was differentially modulated by force-matching version with smaller amplitude over the most right parietal cortex for dynamic force-matching (BS_static > BS_dynamic; US_staic > US_dynamic).
CONCLUSION: Performance outcomes varied differently with task-load of a postural-suprapostural task, in relation to selective information processing and intricate resource allocation.

IMMEDIATE CHANGE IN HIP KINEMATICS AND KINETICS OF INDIVIDUALS WITH TOTAL HIP ARTHROPLASTY AFTER A WALKING EXERCISE FOCUSING ON ANKLE MOTION

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AIM: To investigate whether a walking exercise focusing on ankle motion can change hip kinematics, moments, and powers in individuals with total hip arthroplasty.
METHODS: Twenty-four volunteers (age: 60.8 ± 5.5 y) with total hip arthroplasty were randomly assigned to the following 2 groups: a walking exercise with decreased ankle pushoff group or walking exercise with increased ankle pushoff group. In the former group, subjects were instructed to push less with their feet while walking. In contrast, in the latter group, subjects were instructed to push more with their feet while walking. After an experienced physical therapist had confirmed that the subjects had learned the modified walking pattern, each exercise was performed at least 10 times on an 8-m course in the laboratory. Subjects were instructed to walk naturally before and after a single exercise session. The hip and ankle kinematics and kinetics data were recorded in the sagittal plane during natural walking using a motion capture system and force plates.
RESULTS: There was no significant difference between the 2 exercise groups with respect to age, height, weight, and kinematics and kinetics factors of hip joint before the subjects undertook the exercise session. Analysis of the kinematics and kinetics data showed significant interactions between exercise and time (pre- and post-exercise) with respect to hip flexion angle, hip flexion moment, hip flexion power (negative), and hip flexion power (positive). After an exercise session with decreased pushoff, the subjects showed increased hip flexion moment and hip flexion power (negative). In the subjects who undertook the increased pushoff exercise, the hip flexion angle, hip flexion moment, and hip flexion powers (negative and positive) were decreased.
CONCLUSION: Walking exercise with decreased pushoff could be used as an effective method to improve hip function during walking in individuals with total hip arthroplasty.

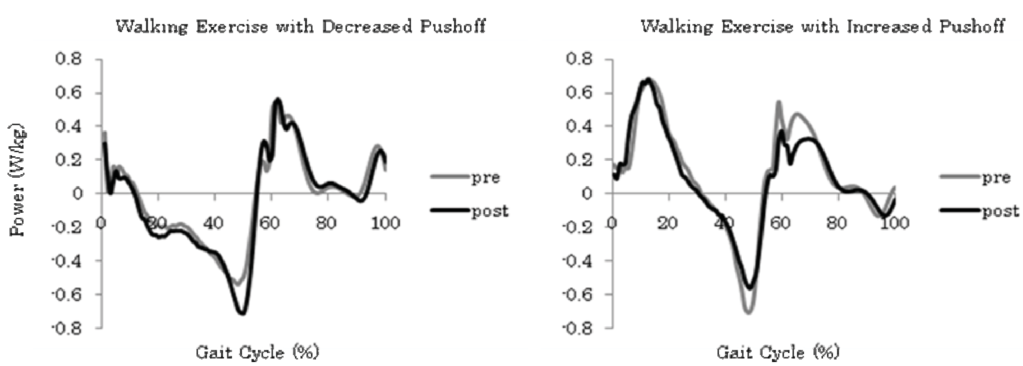

Figure 1: Representative hip power in the sagittal plane for the subjects in each exercise group.

EFFECTS OF THE AQUATIC AND LAND PLYOMETRIC METHODS ON THE VERTICAL JUMP AND THE DELAYED ONSET MUSCLE SORENESS PERCEPTION IN SOCCER PLAYERS

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AIM: The aim of this study was to compare aquatic (APT) and land plyometric methods (LPT) on the vertical jump, the foot contact time and the delayed onset of muscle soreness (DOMS) in soccer players.
METHODS*:* This study included 23 soccer players between 16 and 18 years. The APT (n=9; 16.4±0.4 years; 68.3±7.54 kg; 179.75±8.13 cm); the LPT (n=8; 16.5±0.5 years; 68.2±7.8 kg; 177±7.4 cm); and a control group (CG), that didn´t performed any kind of jump program. The groups underwent identical training programs twice a week for six weeks totaling 944 counter movement jumps (CMJ). The vertical jump was evaluated on a leap jump platform (Axon Jump) to evaluate the height of jump and the foot contact time, and the change in DOMS perception was measured by the Ratio-10 Borg Scale.
RESULTS: It was observed a significant increase on the vertical jump height of the LPT group (p=0.001) and the APT group (p=0.000). There was a significant reduction ($p<0.05$) on foot contact time with the ground in the APT group when compared to the LPT and CG groups. A significant reduction on perception of DOMS was verified for the APT group in comparison to the LPT group (p=0.001).
CONCLUSIONS: The plyometric aquatic training can increase the vertical jump height too, and significantly to reduce the foot contact with the ground and the perception of DOMS in soccer players.

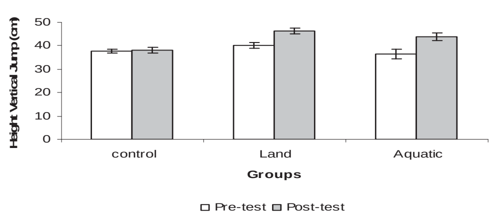

Figure 1. Vertical jump height among the groups. The LPT group presented the highest vertical jump (LPT x CG; $p<0.05$; APT x CG; $p<0.05$).

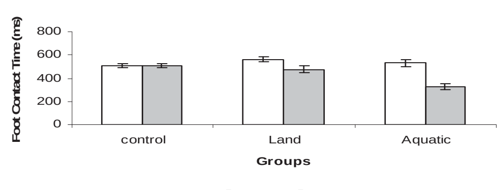

Figure 2. Foot contact time on the ground among the groups. It can be observed the lowest foot contact time in favor of the APT group (APT x LPT; $p<0.05$).

THE EFFECT OF ELECTRODE LOCATION ON SURFACE EMG OF THE VASTUS INTERMEDIUS MUSCLE

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AIM: Recently, we developed a technique for recording surface electromyography (EMG) from deeper part of the quadriceps femoris muscle group, i.e. the vastus intermedius muscle (VI) (Watanabe and Akima. J Electromyogr Kinesiol 2009). In this technique, surface EMG of VI could be detected only from the distal portion of the muscle because the superficial region, which was the only part where we could attach surface electrodes, is located at the distal portion of VI. The aim of this study was to determine the effect of electrode location on surface EMG of VI. We compared the results of surface EMG of VI with those of needle EMG detected at the distal and middle portions of VI. If the electrode location affects the surface EMG of VI, then the pattern of these signals should show greater similarity with that of needle EMG detected at the distal rather than that at the middle portion of VI.

METHODS: Five healthy male volunteers performed 3 ramp incremental contractions (0-30% of maximal voluntary contraction) during isometric knee extension. During the task, surface EMG and needle EMG were simultaneously recorded from VI. Surface EMG were recorded from the superficial distal region of VI, which was defined using ultrasonography. Needle EMG were recorded from the distal and middle portions of VI. Under the ultrasonographic guidance, needle electrodes were inserted near the surface electrodes for the distal portion and at the approximate center of the thigh for the middle portion. The root mean squares (RMS) of the EMG at 10 different force levels were calculated during 3 contractions. Using these 30 RMS values for each electrode, correlation coefficient analysis was performed between EMG detected by needle electrodes at two portions and those detected by surface electrodes. The correlation coefficients of surface EMG and needle EMG at the distal portion (S-ND) were compared with those of surface EMG and needle EMG at the middle portion (S-NM) using z-transform.

RESULTS: No significant differences were observed between the correlation coefficients of S-ND and S-NM for 3 subjects. For 1 subject, the correlation coefficients of S-NM were significantly higher than those of S-ND ($p < 0.05$), whereas the inverse was true in the case of another subject ($p < 0.05$). (Table1)

CONCLUSION: For 4 of 5 subjects, the signal patterns of surface EMG of VI were not more similar with that of needle EMG detected at the distal portion than that of needle EMG detected at the middle portion of VI. Therefore, we concluded that electrode location has no apparent effect on surface EMG of VI recorded from the distal portion of muscle.

Table 1: Comparison of correlation coefficients of needle EMG recorded at the distal and middle portions with surface EMG of VI for each subject. S-NM, surface EMG and needle EMG at the middle portion; S-ND, surface EMG and needle EMG at the distal portion.

Subject	Correlation coefficient		Results of Z-transform
	S-NM	S-ND	
A	0.95	0.97	n.s.
B	0.97	0.90	p < 0.05 (S-NM > S-ND)
C	0.90	0.98	p < 0.05 (S-NM < S-ND)
D	0.98	0.97	n.s.
E	0.95	0.96	n.s.

MUSCLE DAMAGE INDUCED BY ELECTRICAL STIMULATION

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AIM: Electrical muscle stimulation (EMS) induces muscle damage. Mackey et al. (2008) showed histological evidence of muscle damage after 180 isometric contractions of the gastrocnemius muscle evoked by EMS (60 Hz, 300 μs), together with an increase in plasma creatine kinase (CK) activity and delayed onset muscle soreness (DOMS). Jubeau et al. (2008) showed that 40 isometric contractions evoked by EMS (75 Hz, 400 μs) decreased maximal voluntary isometric contraction torque, developed DOMS, and increased serum CK activity. Black and McCully (2008) reported that changes in T2 relaxation time of magnetic resonance images and DOMS following 80 lengthening contractions of the quadriceps femoris stimulated by EMS (100 Hz, 450 μs) were significantly smaller after the second bout compared with the first bout that was performed 7 weeks earlier. However, no previous study has investigated whether the magnitudes of muscle damage is attenuated in the second EMS bout consisting of isometric contractions. It should be also noted that all of the previous studies used pulsed current EMS to investigate muscle damage in EMS. Therefore, the first aim of this study was to compare between two bouts of pulsed current EMS consisting of 40 electrically evoked isometric contractions of the knee extensors separated by 2 weeks, and the second aim was to compare alternating current and pulsed current EMS for muscle damage.
METHODS: Nine men had two bouts of pulsed EMS (75 Hz, 400 μs) for the same leg separated by 2 weeks in the first study, and 12 men received alternating current EMS (2.5 kHz delivered at 75 Hz, 400 μs) for one leg and pulsed current (75 Hz, 400 μs) for the other leg separated by 2 weeks to induce 40 isometric contractions (on-off ratio 5-15 s) of the knee extensors at the knee joint angle of 100° (0°: full extension), while the current amplitude was continuously increased to a maximally tolerable intensity. Maximal voluntary isometric contraction torque (MVC) of the knee extensors at 100°, muscle soreness, pressure pain threshold, and plasma CK activity were measured before and 1, 24, 48, 72 and 96 h after EMS bout. The changes in these variables over time were compared between bouts and between the two current conditions by a two-way repeated measures ANOVA.
RESULTS: The torque produced during exercise was approximately 30% of MVC, and no significant differences between bouts and current conditions were evident for the changes in peak and average torque over 40 contractions. MVC decreased significantly ($P<0.05$) by 20-30% at 1 h after both bouts, but the recovery was significantly ($P<0.05$) faster after the second bout (100% at 96 h) compared with the first bout (81% at 96 h). Development of muscle soreness and tenderness, and increases in plasma CK activity were significantly ($P<0.05$) smaller after the second than the first bout. Both current conditions produced similar torque over 40 contractions and resulted in similar muscle damage evidenced by prolonged loss of MVC, DOMS, and increases in plasma CK activity (peak value: ~1,500 $IU\cdot L^{-1}$).
CONCLUSION: These results indicate that muscle damage is induced by EMS-evoked isometric contractions regardless of the type of current, but the magnitude of muscle damage is not as severe as that could be induced by maximal eccentric exercise. The magnitude of muscle damage in EMS is attenuated in the second EMS bout. It appears that the muscle damage was due to isometric contractions at a long muscle length, not EMS per se. Thus, muscle damage should not limit the use of EMS in training and rehabilitation.
REFERENCES: Mackey et al. *J Appl Physiol* 105:1620-1627, 2008. Jubeau et al. *J Appl Physiol* 104:75-81, 2008. Black & McCully. *Med Sci Sports Exerc* 40:1605-1615, 2008.

ON EVALUATION OF CURVED ANGLE OF LORDOSIS AND KYPHOSIS IN VERTEBRAE ESTIMATED FROM BOTH LENGTH AND WIDTH OF VERTEBRAE FOR NORMAL ADULTS

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AIM: It has been difficult to estimate accurately curved angles of lordosis of thoracical vertebrae, kyphosis of lumber vertebrae, and sacrum with use of image of x-rays, as compared with the estimation of length and width of vertebrae. The aim is to evaluate accurately the curved angles of lordosis, kyphosis, and sacrum with only use of distance information (i.e., length and width of vertebrae).
METHODS: The data of length, width, and curved angle in vertebrae are measured from X-ray for normal male adults aged from 20 to 39 years. The nine data listed in Table 1 are used for evaluation of the curved angles. The data for each subject are normalized to be divided by height of the subject. The curved angles are estimated by multiple regression analysis with use of nine items of length and width listed in Table 1. The precision is examined with multiple correlation coefficient and coefficient of determination. The estimated and the measured angles are compared.
RESULTS: The mean measured angles of vertebra for subjects are 37.9 degree for thoracic vertebra, 31.1 degree for lumber vertebra, and 32.3 degree for sacrum. These angles denote similar. The results of multiple regression equation for curved angles of lordosis of thoracical vertebrae and kyphosis of lumber vertebrae show that multiple correlation coefficient (coefficient of determination) are 0.84 (0.71) and 0.85(0.73), respectively. The result of scrum is 0.72(0.50). These correlations between estimated curved angle and distance data listed in Table 1 are high significantly by 1%. The contribution for items of length and width to multiple regression equation denotes to similar degree. Therefore, the nine items taken are necessary to estimate the curved angles of vertebrae. As the items are divided by subject's height, it is possible to remove individual difference in the estimation of the curved angles. The measured data of curved angles are in good agreement with the estimated curved angles.
CONCLUSION: It is found that the curved angles of lordosis of thoracical vertebrae and kyphosis of lumber vertebrae are possible to estimate in high precision with use of distance of length and width of vertebrae. The angle for inclination of sacrum is also estimated.

Table 1: Nine Items of length and width used for evaluation of curved angles of vertebrae

Items	Contents of Items *
A	C2 to L5 (Length between lower end of cervical and lumber vertebrae)
B	C7 to L5 (Length between lower end of cervical and lumber vertebrae)
C	L1 to L5 (Length between upper and lower end of lumber vertebrae)
D	Width between apices of curve in cervical vertevra and thoracic vertevra
E	Width between apices of curve in thoracic vertevra and lumber vertevra
F	Width between apices of curve in cervical vertevra and lumber vertevra
J	Width between apices of curve in cervical vertevra and vertical line from heel
K	Width between apices of curve in thoracic vertevra and vertical line from heel
/ L	Width between apices of curve in lumber vertevra and vertical line from heel *

EXTREME HIGH PASS FILTERING AND WHITENING TO REMOVE THE FATIGUE ARTIFACT IN SURFACE EMG AMPLITUDE

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AIM: The purpose of this study was to evaluate the use of extreme highpass filtering or whitening of surface EMG signals (sEMG) to remove the amplitude artifact associated with peripheral muscle fatigue. Previously, Potvin and Brown (2004) have shown that these techniques can improve EMG based muscle force estimates under rested conditions, and it is hypothesized that most of the fatigue related artifact occurs in the lower frequency range.
METHODS: Twenty three males participated in the study (25.78+6.69 years, 82.5+13.72 kg, 1.77+0.13 m). sEMG was placed over the biceps brachii, brachioradialis, and triceps brachii and collected at 4096 Hz. Subjects were seated and their upper and lower arms were parallel to the table, while flexed at 90 deg. The lower arm was fastened to a frictionless device that rotated about the elbow. Moments about the elbow were monitored with a force transducer placed in series with a cable, which was attached to the frictionless device at approximately the wrist. Subjects performed a series of isometric, nonisotonic contractions of the elbow flexors by following force feedback on an oscilloscope. Subjects then performed a prolonged isometric contraction at 40% of maximum voluntary efforts (MVE) to fatigue the elbow flexors. After this, the same pattern of isometric contractions was repeated. sEMG signals were processed using signal whitening and a series of high pass filters using 1st and 6th order filters with high pass cutoff frequencies from 20Hz (current standard) to 450Hz in increments of 50Hz. Signals were then be full wave rectified, normalized to the signal's MVE maximum and passed filtered at 1.5Hz. The resulting signal from each method were compared to the elbow extensor moment, normalized to 100% MVE. This was done with the signals recorded before, during and after the fatiguing bout.
RESULTS: During the fatiguing bout, the standard bandpass filtering (20-500 Hz) resulted in an average sEMG amplitude that was 47% higher than the 40% MVE elbow moment. This decreased steadily as the highpass filter cutoff was progressively increased and the error was only +11% with a 450-500 Hz bandpass filter and +1% with EMG whitening. During the post fatigue isometric trial, the standard processing resulted in EMG amplitudes that were an average of 16% higher than the average elbow joint moment. However, highpass filtering the EMG from 140-500 Hz (6^{th} order filter) and 410-500 Hz (1^{st} order) resulted in average artifacts of only +3% and +7%, respectively. Further, the artifact associated with signal whitening was only +1%.
CONCLUSION: It was concluded that extreme highpass filtering and whitening may provide a solution to the fatigue artifact that artificially increases the EMG-to-force ratio and contaminates efforts to estimate muscle force under fatigued conditions. It appears that most of the fatigue related changes in the EMG power occur in the lower frequency range and that extreme highpass filtering or whitening can remove this effect. These data will have implications for the validity of using surface EMG to estimate force from fatigued muscles.

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CUMULATIVE LUMBAR DISORDER: MOTOR CONTROL, BIOMECHANICS, TISSUE BIOLOGY & STABILITY

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AIM: Cumulative Lumbar Disorder (CTD) is common in individuals engaged in long term performance of repetitive and static occupational/sports activities with the spine. The triggering source of the disorder, the tissues involved in the failure and the biomechanical, neuromuscular, and biological processes active in the initiation and development of the disorder are not fully known as an integrated interactive model.

METHODS: The hypothesis is forwarded that static or repetitive lumbar flexion-extension and the repeated stretch of the various viscoelastic tissues cause micro-damage in their collagen fibers followed by an acute inflammation, triggering pain and reflexive muscle spasms/ hyper-excitability. Continued exposure to activities converts the acute inflammation into a chronic one, viscoelastic tissues remodeling/degeneration, modified motor control strategy and permanent disability. Transient changes in lumbar stability are expected during the development of the disorder. EMG, Creep, cytokines analysis and lumbar stability were assessed throughout cyclic loading at various loads and durations.

RESULTS: An interactive model based on a series of experimental data from in-vivo feline and normal humans is presented, demonstrating that prolonged cyclic lumbar flexion-extension induces transient creep/laxity in the spine, muscle spasms and reduced stability followed, several hours later, by an acute inflammation/tissue degradation and muscular hyper-excitability and increased stability.

CONCLUSION: The major findings assert that viscoelastic tissues sub-failure degradation is the source of CTD and their inflammation is the process which governs the mechanical and neuromuscular characteristic symptoms of the disorder. The experimental data validates the hypothesis as well as provide insights into the development of potential treatment and prevention of CTD.

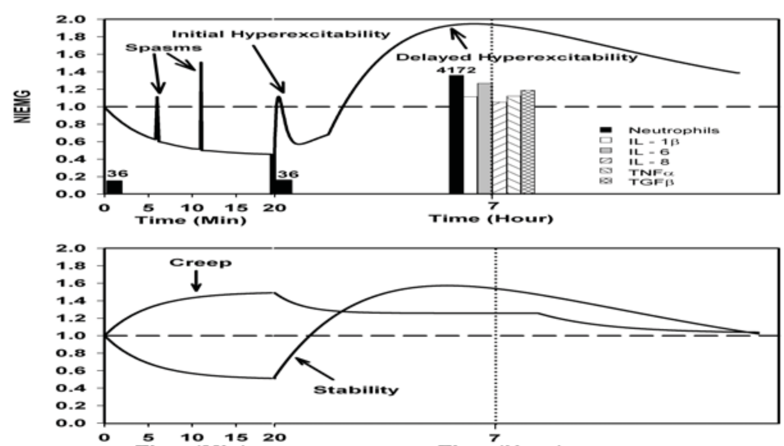

Figure 1: Interactive model graphics of EMG, Creep, Cytokines and Stability during & following cyclic loading.

EVALUATION OF CHANGES IN MUSCLE ACTIVITY OF THE CERVICAL FLEXOR MUSCLES BY USE OF mfMRI

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AIM: Chronic neck pain has been shown to be associated with motor dysfunction. Muscle functional magnetic resonance imaging (mfMRI) is an innovative technique to evaluate muscle activity and enables to evaluate the different function of deep and superficial muscles. The mfMRI technique is based on an activity-induced shift in T2 relaxation time of muscle water following exercise. Increased T2 of muscle water is reflected in a significant augmentation of the signal intensity of the activated muscles and provides information regarding the pattern and the intensity of the muscle activation.
The purpose of this study is 1) to compare the muscle activity between patients with whiplash associated disorders (WAD) and controls during cranio-cervical flexion (CCF) using mfMRI and 2) to evaluate the effect of induced muscle pain on muscle activity in healthy controls.
METHODS: Fourteen healthy controls (7 men and 7 women; mean age 22.2 ± 0.6 years) and 16 patients with WAD (5 men and 11 women; mean age 32.9 ± 12.7 years) participated in this study. In both groups, axial images were obtained 1) at rest and 2) after CCF. In addition, healthy controls were also scanned after CCF with induced muscle pain. Acute muscle pain was elicited by injection of hypertonic saline in the right trapezius muscle. T2 values were calculated for the longus colli (Lco), longus capitis (Lca) and sternocleidomastoid (SCM), and T2 shifts, which are defined as the difference between T2 values at rest and after exercise, were used for statistical analysis
RESULTS: When comparing healthy controls and patients with WAD, the overall statistical model for T2 shift revealed a significant main effect for muscle ($F=3.906$; $p=0.033$) but not for group ($F=2.855$; $p=0.101$). The muscle by group interaction effect was significant ($F=3.618$; $p=0.041$). Although not significant, there was a strong trend for lesser Lco ($p=0.061$) and Lca ($p=0.060$) activity for the group with WAD. Although the SCM showed higher T2 shifts, this difference was not significant ($p=0.291$).
The data for the comparison between the pain and non-pain condition in healthy subjects are currently incorporated and will be available in february 2010.
CONCLUSION: MfMRI could demonstrate a difference in muscle recruitment between the Lco, Lca and SCM during CCF, but failed to demonstrate a changed activity pattern in WAD patients compared to healthy controls. The mild symptoms in the WAD group may have caused the lack of significance.
ACKNOWLEDGEMENT: This study was supported by the Research Foundation - Flanders (FWO)

CORRELATION BETWEEN BIOMECHANICAL OUTCOME AND MUSCULAR CO-ORDINATION IN PATIENTS WITH GONARTHROSIS

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AIM: Due to pain patients with Gonarthrosis often show differences in gait which became less when treated with a knee joint endoprosthesis. Since the pathological gait patterns are usually initialized by abnormal muscular co-ordination, it can be assumed that not only the movement pattern but also the muscular co-ordination recovers after treatment. In order to monitor the patients' individual recovery after knee endoprosthesis, two quantitative parameters have been introduced, which assess the degree of pathology of both the individual muscular co-ordination and the individual gait pattern.
METHODS: Surface-EMG was derived from the standard 8 leg muscles commonly investigated during clinical gait analysis. Patients walked in their individual gait rhythm and velocity. Surface EMG electrodes were placed on the muscles according to SENIAM recommendations. In order to compute the EMG envelope, the signals were rectified and smoothed using a moving-average filter. The envelopes were normalized to the maximal amplitude, synchronized to the gait cycle and averaged over 15 steps. Additionally pelvic, hip, knee and ankle joint angles have been measured by a VICON movement analysis system. 7 patients with Gonarthrosis have been investigated before knee joint endoprothesis and between 3 to 6 months after the operation. For each patient the detected activation pattern of each muscle as well as the individual gait pattern was compared to a norm of 25 healthy volunteers of same age and sex. Both, individual muscular co-ordination as well the individual gait pattern, have been assessed by calculating two quantitative parameters 1) the area outside the 95% confidence interval of the norm and 2) the percentage of the gait cycle outside the norm (Figure 1).

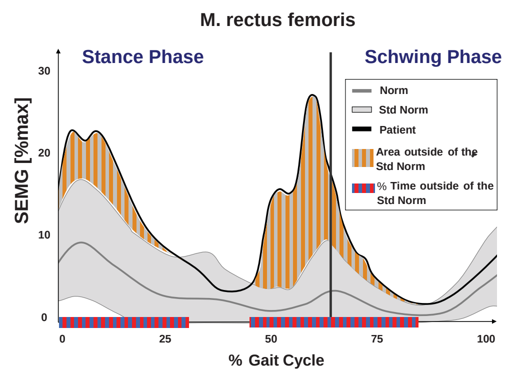

Figure 1: Quantitative evaluation of pathology

RESULTS: With exception of the Adductors and the Gluteus Medius the muscular co-ordination as well the gait pattern of patients show preoperatively significant differences compared to healthy subjects, which improve tendentiously after operation. This is reflected in the parameter values, which decrease postoperatively. However, a significant (ttest: $p<0.05$) decrease of the parameter values can only be seen in the Vastus Lateralis- and Hamstrings-EMG. This is consistent to the changes in the gait pattern, in which only for the knee flexion/extension a normal range of motion is reached. In all other joints compensation-movements still remain.
CONCLUSION: Like the biomechanical function of gait the muscular co-ordination pattern 3-6 months is not restored completely after knee joint endoprosthesis. This is reflected in the parameter values, which have been shown to be suitable for a monitoring of the patients' individual recovery.

NEUROPHYSIOLOGICAL ASPECTS AND THEIR RELATIONSHIP TO CLINICAL AND FUNCTIONAL IMPAIRMENT IN PATIENTS WITH CHRONIC OBSTRUCTIVE PULMONARY DISEASE

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AIM: The neurophysiological alterations often found in patients with chronic obstructive pulmonary disease (COPD) are associated with the severity of the disease. Other factors, may have a negative impact on these neurophysiological aspects and compromise their functional activity. The purpose of the present study was identify a possible functional and prognostic assessment by neurophysiological aspects and their relationship to clinical and functional impairment in patients with COPD.
METHODS: A cross-sectional study was carried out involving three groups of patients: COPD group (not dependent on oxygen); COPD-O_2 group (dependent on oxygen); and control group (CG, healthy individuals paired for age). To evaluation tests for neurophysiological aspects was: the electromyographic signal (monosynaptic reflex); peripheral muscle strength; the pressure plate (MatScan model) was used to assessment of balance by means of the center of oscillatory pressure; the Tinetti Scale was used for the assessment of gait as well as static and dynamic balance; and the Sit-to-Stand Test (SST). As all data were parametric, one-way analysis of variance (ANOVA) was used to compare the means of the data between the three groups and Tukey's DHS test for the multiple comparisons of means was used in the presence of significance for the analysis between posts. The Student's t-test was used for the comparison of means between the COPD and COPD-O_2 groups only for the total BODE Index score. Person's correlation coefficient was used to determine the degree of association between two variables in the same group. The level of significance was set at 5%, with an α of 0.05 and β of 0.01.
RESULTS: The individuals with COPD had a reduced reflex response (evident the by increase in latency time of the patellar and Achilles reflexes), achieved a lower number repetitions on the SST and exhibited lesser peripheral muscle strength on the femoral quadriceps muscle when compared to the CG. No statistically significant differences were found between the COPD and COPD-O_2 groups regarding the neurophysiological aspects analyzed. The BODE Index demonstrated correlations with balance assessment (determined by the Tinetti scale) and the SST. Both COPD groups had similar characteristics regarding the total BODE score and neurophysiological aspects, which justifies pooling the two groups for the correlation analysis between these variables (COPDt Group). Statistically significant strong and moderate negative associations ($p < 0.05$) for the Tinetti Scale and SST, respectively. Correlations were weak for the other variables.
CONCLUSION: Both are functional tests and lower scores suggest a worse prognosis for individuals with COPD, which speaks to the need for further investigations. These tests are easy to administrate, low-cost and feasible, especially the SST, and may represent a new assessment modality for prognoses in COPD that is more easily administered than the BODE Index.
ACKNOWLEDGEMENTS: FAPESP, process n° 2007/06078-0.

MOVEMENT ANALYSIS BY ACCELEROMETRY OF NEWBORNS AND INFANTS FOR THE EARLY DETECTION OF MOVEMENT DISORDERS DUE TO INFANTILE CEREBRAL PALSY

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AIM: So far developed diagnostic strategies for the early detection of movement disorders due to infantile cerebral palsy (ICP) in newborns are not easily applicable in clinical settings. They are either highly subjective or they are too expensive to be established in pediatric clinics and not sufficiently usable to be integrated into daily routine. Therefore a methodology has been developed which allows the objective detection whether newborns are at risk or not of developing movement disorders due to ICP and which is applicable to pediatric offices and can be easily integrated into daily routine.
METHODS: The measurement setup is based on 4 light-weight (weight: 1g), triaxial accelerometers which are attached to the hands and feet of the newborn. The acceleration data is recorded during 2 min. of the spontaneous movement of the newborn. 32 parameters are extracted out of the accelerometer data. A genetic algorithm reduces these parameters depending on age to the optimal number and combination of the parameters to form the basis for the subsequent classification of the patients. To differentiate between healthy and pathological patients a classificator based on a decision tree algorithm is implemented to propose whether an individual newborn is at risk or not.
RESULTS: The developed methodology was validated in a clinical study with 19 healthy and 4 affected subjects that were evaluated at the first, third and fifths month after birth (corrected age). The overall detection rate of the developed methodology reached between 88% and 92% for all evaluated measurements.
CONCLUSION: The developed methodology is simple to use, therefore is applicable for the objective diagnosis of developing movement disorders in newborns due to ICP and it can be established in pediatric offices for use in daily routine.
ACKNOWLEDGEMENT: The authors gratefully acknowledge the financial support provided by the German Research Council (Deutsche Forschungsgemeinschaft DFG, DI 596/5-1).

Table 1: Classification results, using genetic algorithm and decision tree.

	1st measurement	**2nd measurement**	**3rd measurement**
Sensitivity	100%	100%	100%
Specificity	83%	86%	89%
Overall detection rate	89%	88%	92%
Positive predictive value	75%	50%	71%
Negative predictive value	100%	100%	100%

NEUROMUSCULAR EFFECTS OF FCU TENDON TRANSFER IN THE RAT

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AIM: Biomechanical and neuromuscular adaptations to an agonist-to-antagonist tendon transfer are not well understood. The purpose of this study was to investigate effects of flexor carpi ulnaris (FCU) tendon transfer (from its flexor to an extensor site of the wrist) on muscle activity patterns and muscle length changes in the rat forelimb during locomotion. METHODS: We implanted EMG electrodes in FCU and palmaris longus (PL) muscles of male Wistar rats. FCU was instrumented also with sonomicrometry crystals to measure changes in muscle belly length. EMG activity and muscle length, as well as wrist and elbow angles in the sagittal plane (i.e., 2D kinematics) were assessed during treadmill walking on a level surface (speed: 0.12-0.54 m/s). After collecting baseline data, FCU was transferred to the distal tendons of extensor carpi radialis muscle (wrist extensor) within the right forelimb. The measurements during locomotion were repeated 2, 3 and 4 weeks post transfer. RESULTS: 2, 3 and 4 weeks post-transfer wrist and elbow joint angles during walking were similar to those joint angles before transfer. In contrast, muscle length patterns during a step cycle were profoundly changed after FCU tendon transfer (Fig. 1). For most of the stance phase of walking, when the wrist flexors are predominantly active, FCU muscle was shortening during wrist dorsi-flexion (as expected from a wrist extensor) whereas FCU lengthening was found before transfer. Length patterns did not change between the 2nd and 4th week. Despite its new mechanical effect at the wrist, the timing of FCU activity (i.e., the occurrence of EMG in the step cycle) was not changed after FCU tendon transfer. However, peak EMG magnitude of FCU decreased substantially 2 weeks post-transfer (by 37%), and even more after 3 (by 47%) and 4 weeks (by 53%). In contrast, peak EMG magnitude of PL increased progressively: by 45% at week 2, by 105% at week 3 and by 120% at week 4. CONCLUSION: The similarity in joint kinematics indicate that the rat adapted to the surgical changes in forelimb anatomy within 2 weeks. FCU shortening during wrist dorsi-flexion indicates that the tendon transfer successfully altered the mechanical effect of FCU from wrist flexion to wrist extension. 4 weeks after tendon transfer, however, the timing of FCU activity was not adjusted to its altered mechanical effect at the joint (i.e., EMG predominantly during swing). The increase in EMG of PL muscle as a response to this inappropriate FCU activity during stance suggests a compensatory strategy to conserve normal joint kinematics.
ACKNOWLEDGEMENTS: Supported by EU grant MIRG-CT-2007-203846 of FP7.

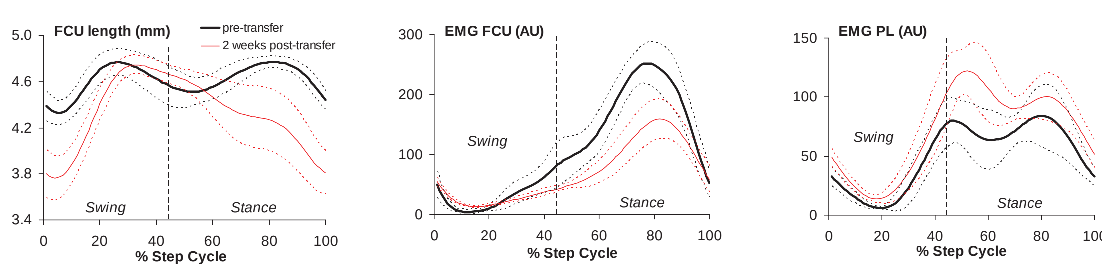

Figure 1: Effects of FCU transfer on FCU length (left), as well as FCU (middle) and PL (right) activity during walking. Baseline and 2 weeks post-transfer data are shown (± SD).

APPLICATIONS OF HIGH-DENSITY SURFACE EMG IN CLINICAL RESEARCH

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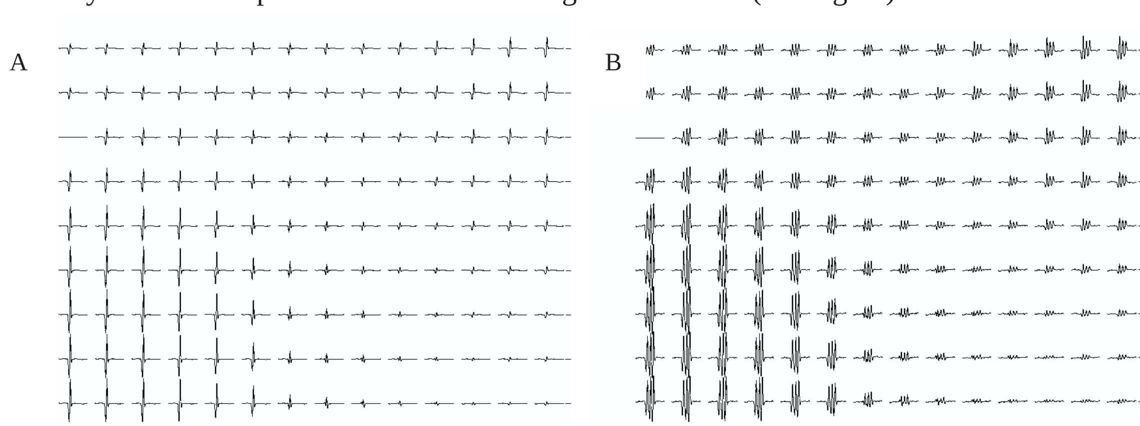
AIM: High-density surface EMG (HDsEMG) recordings can answer clinical and scientific questions that often cannot be answered in any other way. Ongoing developments in data acquisition methodology and signal analysis have resulted in HDsEMG techniques that are fairly easy to apply in clinical conditions. However, HDsEMG recordings are still more complex and time-consuming than conventional EMG. Most clinical applications of HDsEMG can therefore be found in the area of clinical research rather than direct patient care. In the presentation, a few of these applications will be presented, split over two main areas of investigation.

1. AT THE LEVEL OF THE MUSCLE: By tracking the propagation of action potentials over the muscle fibers (i.e., from one electrode to the next), quantitative information regarding at least three clinically relevant variables can be extracted. The first is the constancy (versus decline) of the action potentials over the muscle fibers, which can provide an indication of muscle fiber ion channel functioning. The second is the velocity of the process of action potential propagation, which tends be lower in myopathies. Thirdly, the propagation pattern can be used to detect the location of the motor endplate zone. This information can be relevant for, for example, determining the optimal location of a surgical incision (away from the endplate) or Botox injection (in the endplate).

2. AT THE LEVEL OF SINGLE MOTOR UNITS: HDsEMG recordings can be used to derive spatiotemporal profiles from single motor units, either through low-level electrical stimulation of the motor nerve or through decomposition of voluntary EMG. These single motor unit profiles or “fingerprints” can, for example, be averaged to derive a motor unit number estimate (MUNE) and hence used to monitor motor unit loss in neurogenic processes. Furthermore, because the profile of a motor unit tends to be very characteristic, units can be tracked over time. This allows the study of a disease process at the level of single motor units (see Figure).



otor unit action potential, showing the MUAP for each electrode at the position f this electrode in the array. The size and shape of the signals are strongly he MU to each of the electrodes. The MU that generated this potential was, r-left corner of the array. B. During follow-up of this subject (a patient with e same MU occasionally generated repetitive discharges (here: a triplet), excitability and, hence, affection by the disease.

ANALISIS OF PRESSURE DISTRIBUTION AND INFLUENCES OF TACTILE INFORMATION FOR THE SITTING BALANCE IN PATIENTS AFTER STROKE

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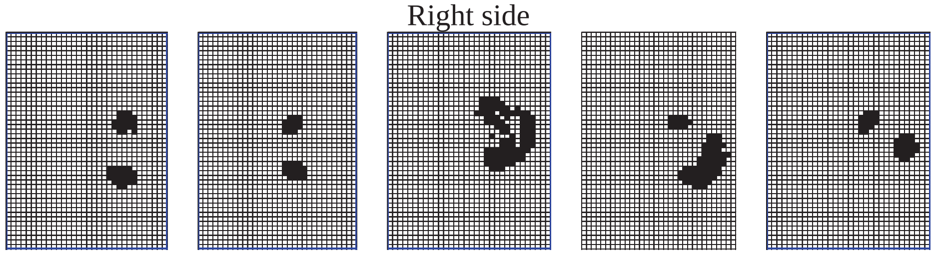
AIM: The purpose of this study was to elucidate whether a tactile information to side of pelvis affect on sitting balance.
METHODS: The participants group were two, ten healthy people (H group) and 16 patients after stroke consisting eight left hemiparesis and eight right hemiparesis (S group). The participants sat on the table without foot support. The sway paths for 30 seconds were measured in quiet sitting and dynamic sitting. As a dynamic sitting task, participants picked pegs up from a board in front of them. The force distribution measuring system (Zebris PDM system) was used to measure sway paths by calculating sitting pressure distribution. As parameters, total locus length (LNG), root mean square (RMS), and numbers of pegs picked up were used.
RESULTS: The results showed that all parameters were lower in dynamic sitting of S group. In dynamic sitting with tactile information, both H and S group picked many more pegs up. This implied that the tactile information toward unaffected side of pelvis might be a cue for keeping dynamic sitting balance. Since participants in S group showed some different patterns of sitting pressure distribution, it might be necessary to provide tactile information in different way depending on their pressure distribution.
CONCLUSION: The tactile information to the unaffected side of pelvis is useful to improve ability of dynamic sitting control after stroke.

Right side



Front / Back

Figure 1: Five examples of the pressure distribution of participants with left hemiparesis in quiet sitting. There are 1504 sensor cells on the PDM system. Cells weighting more than 1N are colored.

Table 1: Influence of the tactile information in the H and S groups.

	H group		S group	
	with no information	**with information**	**with no information**	**with information**
LNG(mm)	4812.83*	4569.93	1869.12	1859.69
RMS(mm)	28.48*	24.31	12.66	12.52
Pegs	35.0*†	36.4	23.9†	24.8

*: significant difference between the H and S groups under conditions of no information.
†: significant differences between conditions of no information and with information in the H and S groups.

CLOSED-LOOP TREMOR ATTENUATION WITH FUNCTIONAL ELECTRICAL STIMULATION

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AIM: Development of the algorithm and apparatus for real-time tremor suppression by functional electrical stimulation (FES).
METHODS: We used gyroscopes to acquire the information about the movement in the wrist. An adaptive band-pass filter is used to distinguish tremor from the voluntary movement in real-time. Stimulators were triggered out-of-phase with tremor to counteract the tremulous movement. The algorithm performance was evaluated in one patient with Parkinson disease.
RESULTS: We succeeded to suppress more than 80% of tremor RMS amplitude.
CONCLUSION: The proposed algorithm requires short adaptation periods with no stimulation after each 4s period to update information about tremor frequency and phase. This can probably be omitted by employment of the EMG recordings. EMG can provide information about tremor onset in the muscle, and therefore could be used to trigger stimulation.
ACKNOWLEDGEMENT**:** Research is supported by the EU FP7 project TREMOR (#224051). We thank UNA systems (www.unasistemi.com) for providing us stimulators for the experiment.

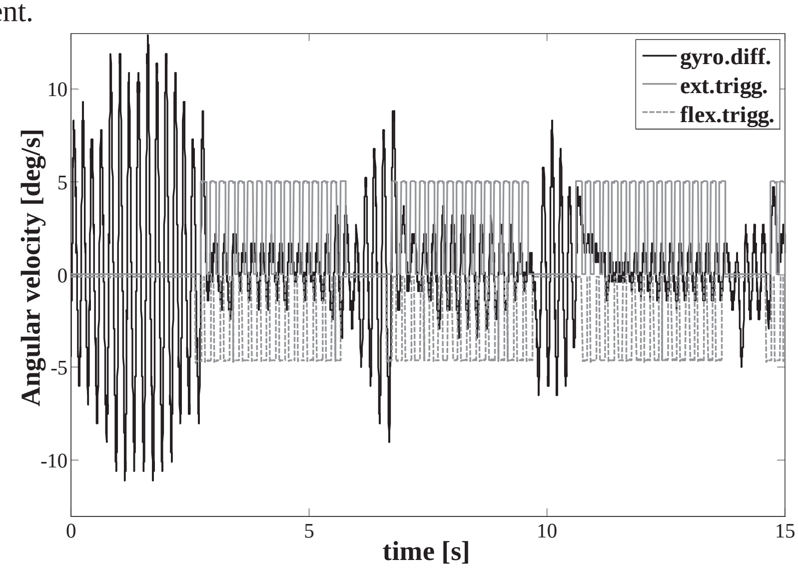

Figure 1: Results for the semi closed-loop FES tremor suppression. Solid black line is the difference between the outputs from two gyroscopes. Solid and dashed gray lines represent extensor and flexor stimulator trigger activation, respectively. The trigger profiles are symbolically presented pointing up and down to suggest the opposing action. When the line is close to zero, the trigger is inactive, otherwise the trigger is active and the stimulation is delivered to the muscle nerves.

COMPARISON OF CAPACITIVE AND CONVENTIONAL SURFACE EMG RECORDINGS OF THE HUMAN BICEPS BRACHII

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AIM: This study investigated the feasibility of using capacitive EMG sensors to quantify muscle activity. These sensors are based on a capacitive coupling between electrode and skin instead of a galvanic contact, meaning that the measurement can be performed contactless, which is potentially advantageous in long-term, ambulant recordings of muscle activity.
METHODS: Capacitive EMG recordings were compared with conventional EMG recordings during isometric contractions of biceps brachii. Both a flex foil (FF) implementation with integrated electronics, and a printed circuit board (PCB) implementation were used as capacitive sensors. Four healthy female subjects performed isometric contractions (0 to 80% MVC, steps of 10%). Root-mean-square (RMS) values and power spectra were calculated.
RESULTS: The two sensor types showed different behavior: the signals obtained with FF sensors were similar to the conventionally obtained signals whereas the frequency spectrum of the PCB sensors showed a remarkable peak around 10-15 Hz. All sensor types showed a strong relation between RMS and force ($0.85<r^2<0.99$) and RMS of both capacitive sensors showed strong correlations with conventional RMS ($0.87<r<0.98$, see Fig. 1). However, RMS values for the PCB sensor were up to 8-fold higher (Fig. 1).
CONCLUSION: The results obtained with the FF sensors indicate that it is feasible to measure EMG with capacitive sensors. The lower frequency content and higher RMS values that were obtained with the PCB sensor may be caused by mechanical muscle vibrations that may result in changes of the distance between skin and electrode (thickness of the insulation layer), which affects the measured potentials. This effect may be enhanced by the presence of static charges, that should be avoided by choosing materials with a triboelectric constant that is close to that of human skin.

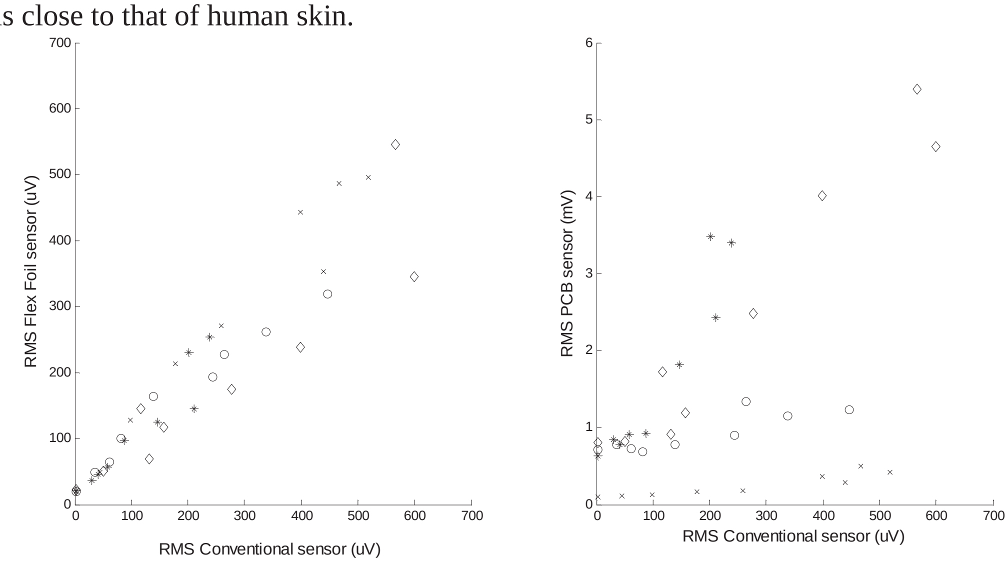

Figure 1: Scatter plot of RMS values of the capacitive sensors against the RMS value of the conventional sensor. Symbols indicate subjects. NB: Scales of the y-axis are different.

DETECTION OF THE MUSCLE – TENDON JUNCTION WITH HIGH DENSITY SURFACE EMG

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AIM: Information extraction from high-density surface EMG (HD-sEMG) signals is often compromised by the non-propagating component that is generated with the extinction of each Motor Unit Action Potential (MUAP) at the muscle-tendon junction (MTJ). Therefore it is of importance to detect the MTJ in the HD-sEMG. The goal of this study was to develop and validate an algorithm that is able to detect the MTJ in the HD-sEMG during dynamic contractions during which the MTJ shifts under the HD-sEMG grid.
METHODS: an algorithm was developed that uses the propagating component of MUAPs in a bipolar derivation and the non-propagating component in a monopolar derivation to estimate the location of the MTJ (Fig 1). First, MUAPs are detected in the bipolar signals using a Continuous Wavelet Transform template matching method. The propagation of the MUAPs is estimated from the time instances of the zero crossing of the MUAP at the different channels. After this, the time instance of the accompanying non-travelling component is estimated in those monopolar signals where the bipolar MUAP shape is sufficiently large by taking the first local maximum that occurs after the propagating component. The intersection of the propagating component and the non-propagating component is the location of the MTJ.
Simulations were done for validation. Signals from 5 and 15 MUs were generated for SNRs between 2 and 50dB. The grid was placed over the MTJ (Fig 1). Results were averaged from 3 repetitions. Experimental data from cyclic elbow flexion and extension contractions (0.2Hz, 6% MVC, elbow angle 100-150°) was obtained from 5 healthy male subjects (age 29, BMI 24.4). MTJ movement under the grid was expected to be related to elbow angle. A 32 channel HD-sEMG electrode grid was applied over the MTJ of the dominant m. biceps brachii.
RESULTS: For SNRs >5dB, the average error was small; -0.5mm and -0.6mm for 5 and 15 MUs (Fig 2). The trend of the cyclic contraction could be followed for 3 subjects (Fig 3).
CONCLUSION: The proposed algorithm seems able to detect the MTJ sufficiently accurate. Validation with more extensive simulations and more experimental data is necessary.

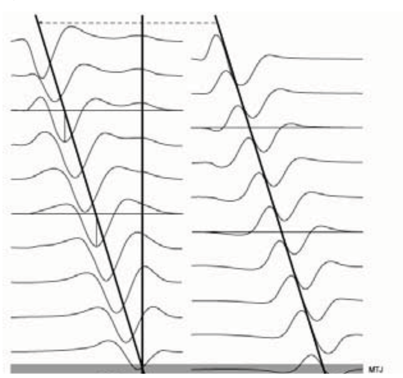

Figure 1: Simulated monopolar (left) and bipolar (right) signals in muscle fiber direction. Grey band indicates MTJ.

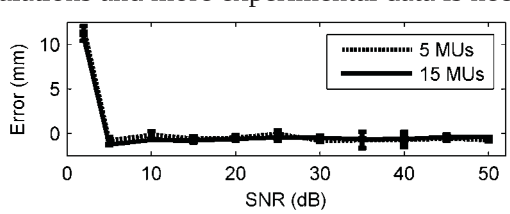

Figure 2: Result of validation with simulation signals.

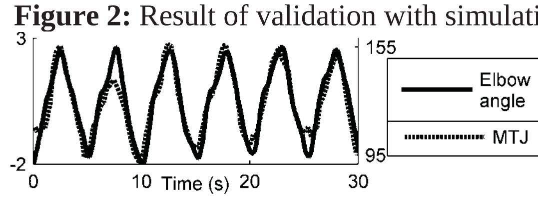

Figure 3: Result of the evaluation with HD-sEMG gnals obtained during a dynamic contraction.

RELATIONSHIP BETWEEN THE PEAK-TO-PEAK RATIO OF SINGLE FIBRE ACTION POTENTIALS AND RADIAL DISTANCE IN HUMAN MUSCLE FIBRES

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AIM: This study aims to analyse the variations of the ratio between the amplitudes of the first and second phases, i.e. peak-to-peak ratio (PPR) [see Fig. 1(a)], of human single muscle fibre action potentials (SFAPs) with radial distance when the recording electrode is in the proximity of the fibre.
METHODS: Using a single fibre electrode, 135 sets of consecutive SFAPs [see Fig. 1(b) for an example] were recorded under needle movement from the *m. tibialis anterior* of five normal subjects. In each SFAP set, the excitation source was assumed to remain unchanged and thus only the fibre-electrode distance varied between consecutive discharges. The changes of SFAP PPR with peak-to-peak amplitude (V_{pp}) within each SFAP set were used to study the relationship between PPR and radial distance [Fig. 1(c)].
RESULTS: SFAP PPR was practically not influenced by changes in SFAP V_{pp} in 73 % of the 135 SFAPs sets recorded under needle movement [Figs. 1(d) and (e)]. Only 27 % of the SFAP sets show a strong correlation between PPR and V_{pp}.
CONCLUSION: The amplitudes of the two phases of a SFAP should change in a similar proportion when the needle is moved in the proximity of a muscle fibre (up to 300 µm).
SIGNIFICANCE: The studies provide greater insight into the formation of the electrical field around a fibre. They are also useful in detecting the proximity to the neuromuscular of fibre-tendon junctions, known to affect the PPR considerably.

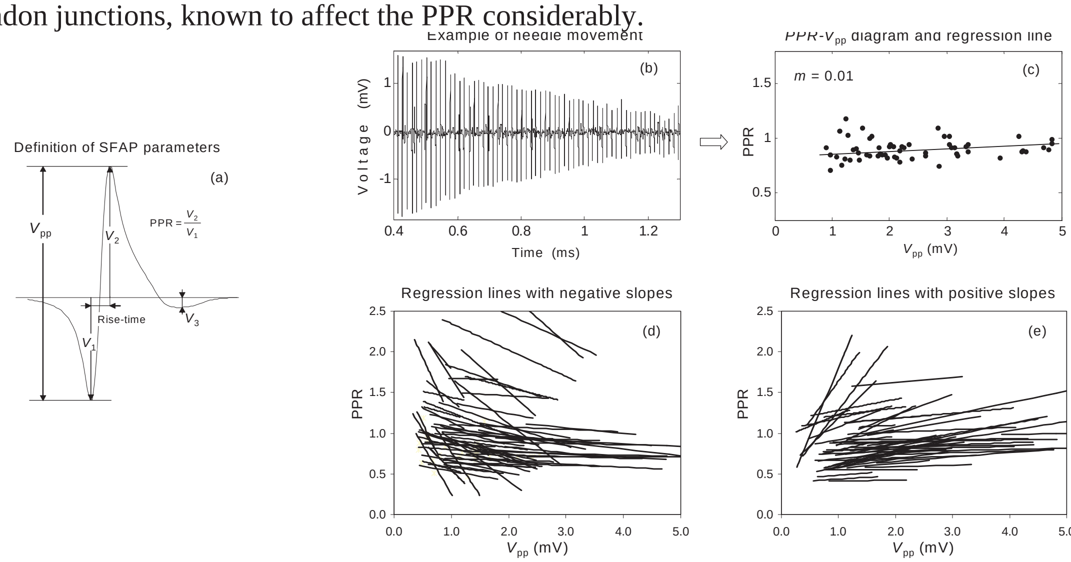

Figure 1: (a) Definition of SFAP V_1, V_2, V_3, V_{pp}, and PPR. A needle movement (b) with its corresponding PPR-V_{pp} diagram (c). The solid line in (c) is the linear regression line; the gradient of this line is given towards the top of the diagram. Representation of all the linear regression curves with slopes less than 0 (d) and greater than 0 (e). Note that most of the lines depicted in (d) and (e) are approximately horizontal, showing that PPR hardly changes with V_{pp} (and therefore with radial distance).

RELATIONSHIP BETWEEN THE RISE-TIME OF SINGLE FIBRE ACTION POTENTIALS AND RADIAL DISTANCE IN HUMAN MUSCLE FIBRES

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AIM: This study aims to check the theoretical predictions of the small changes in the rise-time [see Fig. 1(b)] of human single muscle fibre action potentials (SFAPs) experimentally when the recording electrode is moved in the proximity of the fibre.
METHODS: Using a single fibre electrode, 93 sets of consecutive SFAPs [Fig. 1(a)] were recorded under needle movement from the *m. tibialis anterior* of four normal subjects. In each SFAP set, the excitation source was assumed to remain unchanged and thus only the fibre-electrode distance varied between consecutive discharges. The changes of SFAP rise-time with peak-to-peak amplitude (V_{pp}) within each SFAP set were used to study the relationship between rise-time and radial distance [Fig. 1(c)].
RESULTS: SFAP rise-time was relatively unchanged when V_{pp} was greater than 1.0-1.5 mV. For V_{pp} smaller than 1.0-1.5 mV, the sensitivity of rise-time to changes in radial distance increased considerably [Fig. 1(d)].
CONCLUSION: SFAP rise-time is essentially determined by the duration of the depolarization phase of the intracellular action potential (IAP) only when SFAP V_{pp} is greater than 1.0-1.5 mV. The studies are useful in diagnostics and following the results of treatment in patients suffering from muscular dystrophy or myopathy, known to be accompanied by severe changes in the duration of IAP.

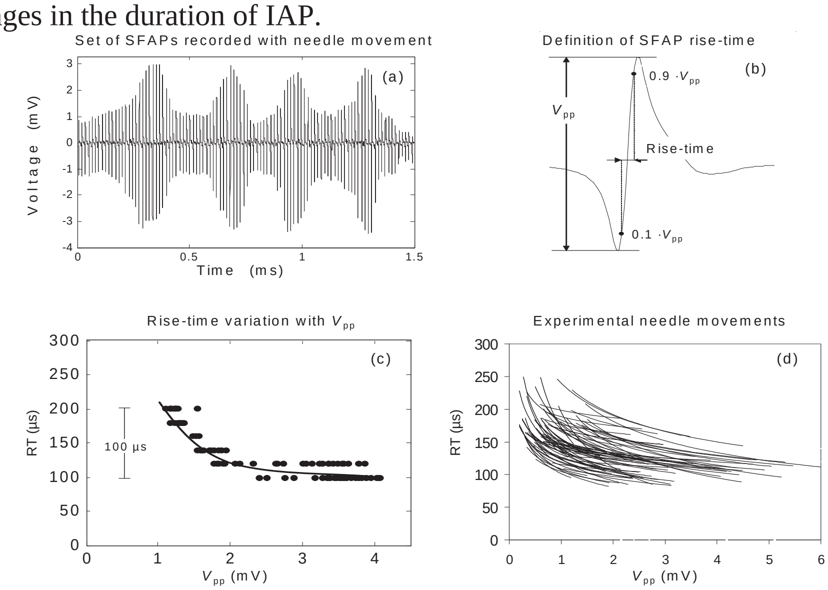

Figure 1: (a) A set of consecutive SFAPs recorded with needle movement. The gradual changes in SFAP V_{pp} reflect the changes in the position of the needle. A total of 100 potentials formed the SFAP set. (b) Definition of SFAP rise-time (RT) and V_{pp}. (c) Relationships between the SFAP RT and V_{pp} for the SFAP set shown in (a). (d) Curves representing the rise-time changes with V_{pp} for 93 SFAP sets. Each curve was calculated from a SFAP set using a polynomial regression algorithm.

“THE FLY” – A NEW CLINICAL ASSESSMENT AND TRAETMENT METHOD FOR DEFICITS OF MOVEMENT CONTROL IN THE CERVICAL SPINE: RELIABILITY AND VALIDITY

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AIM: To determine the test-retest reliability and the discriminative validity of the new Fly method®
METHODS: Test-retest and case-control study was conducted on three groups with 18 subjects in each group: An asymptomatic group; a chronic non-trauma group; a group with chronic whiplash–associated disorders (WAD), grade II, after one car collision. A sensor was mounted on the subjects head and the attempt required the subjects to track a moving fly that appeared on a computer screen by moving the head and neck. The fly drew three incrementally difficult and unpredictable movement patterns: easy – medium – difficult. Each pattern was repeated three times in random order. Amplitude accuracy (deviation of movements), directional accuracy (time on target, undershoots vs. overshoots) were compared across patterns and groups on two occasions.
RESULTS: The $ICC_{2,1}$ ranged from 0,53 to 0,82 for both variables, except for the sub-variable “overshoots” (0,14 – 0,42). The limits of agreement (LOA) were progressively wider across patterns (easy – medium – difficult) and groups (asymptomatic – non-trauma – WAD). Analysis of variance with repeated measures revealed significant differences between patterns within each group and between groups respectively for both outcome variables ($P <$ 0,001).
CONCLUSION: The Fly method provides reliable and valid measures for movement control of the cervical spine. Larger variability for higher test values is reasoned to be inherent in the new method and the subject groups tested. The wide LOA in the WAD group support the development of a normative database. The new Fly method can be used both as an assessment and treatment method. The treatment can be started on each patient's respective impairment level and ensures gradual progression in the treatment for deficits of movement control in patients with neck pain.

FUZZY INFERENCE BASED BIOFEEDBACK CHANGES EMG ACTIVITY IN TRAPEZIUS DURING STANDARDIZED COMPUTER WORK

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AIM: To develop a fuzzy inference based biofeedback system and investigate its effects on the trapezius muscle SEMG activity during computer work compared to no biofeedback
METHODS: Thirteen healthy subjects participated in the experiment. SEMG signals were recorded from clavicular, descending (bilateral) and ascending parts of the trapezius muscles during computer work. EMG signals of upper trapezius were also recorded using multichannel electrode grid. The subjects performed three sessions of 10 minutes computer mouse-work. Two types of feedback instruction (passive and active pause), beside a no feedback trial were used in a randomized order. The feedback instructions were given based on an advanced feedback decision machine. Five second epochs of EMG with 2 seconds overlap of ipsi-lateral clavicular and descending parts were fed to the decision machine. Normalized RMS and permuted sample entropy (PeSaEn) were calculated over 500 ms segments. For each entry (RMS and PeSaEn), three fuzzy linguistic attributes ("LOW", "MEDIUM" and "HIGH") were defined based on EMG recording during resting and a reference contraction (flexed forearms in 90º). Membership functions readjusted based on history of stored inputs to the fuzzy system. To assess the feedback effect on PeSaEn and RMS the moments corresponding to feedback time were excluded.
RESULTS: The type of feedback instruction played a significant role on PeSaEn in the clavicular and ascending parts ($P<0.05$). PeSaEn during active pause was lower in clavicular and larger in ascending parts compared with PeSaEn during no feedback and passive pause. Feedback instruction also played a significant role on normalized RMS on both ipsi and contra-lateral descending parts ($P<0.05$). Normalized RMS increased (for ipsi and contra-lateral descending parts) during active pause compared to no feedback.
PeSaEn decreased over whole EMG multichannel map in response to active pause ($P<0.05$) but the entropy of RMS maps increased in response to active pause session compared with no feedback session ($P<0.05$).
CONCLUSION: Active pause resulted in more heterogeneous coordination of trapezius as a whole implying a more uneven distribution of the biomechanical load. However extensive active pause may have an accumulative fatiguing effect as highlighted in increased amplitude in upper trapezius. The study introduced new aspects of the potential benefit of active pause regarding the spatial organization of muscle activity during computer work.

UNIFIED EEG-SEMG PLATFORM FOR ACCELERATED RECOVERY OF MOTOR FUNCTION AFTER STROKE

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AIM: The population of persons disabled after stroke has risen dramatically in the past decade, far outstripping the required number of therapists who can administer long term therapy. The effectiveness of rehabilitation will be increased substantially if the patients are able to use a robotic rehabilitation system at home, after having trained on it at the hospital. The design described in this paper involves an integrated system that can sense brain and muscle signals with adequate reliability to run a hand function orthosis or electrical stimulation device for hemiplegic stroke patients, providing passive and “active” therapy.

METHODS: The key factors which maximize the benefits of brain plasticity are “intensity” of therapy and “engagement” of the patient at mind and body levels, among others. This system is designed to have:

1) The ability to accept both EEG to SEMG as inputs, interchangeably, with bio-feedback.
2) Portability and versatility with a gaming interface.
4) Modified electrode system with a simple arm glove system and non-gel headset design.

RESULTS: Results of some of the SEMG and EEG experiments were reported in various publications. Studies with healthy subjects have shown a high level of operability of SEMG based games. Frequency responses of the system for both simulated micro-voltages as well as real EEG signals have been shown to be satisfactory for quantitative analysis. Changes in alpha wave in occipital lobe due to eyes closure (blink) can be tapped for trigger-based operation of orthosis or initiation of FES. The setup with gaming interface is shown in Figure 1.

CONCLUSION: The system will enable a person to work alternatively or jointly with mind and body. The system will enable a patient to alternate between active and passive therapy. In addition, alternating between robotic movement and FES may allow for better fatigue management and more options in the hands of the therapist and patient. The system is now undergoing Phase I trials with stroke patients.

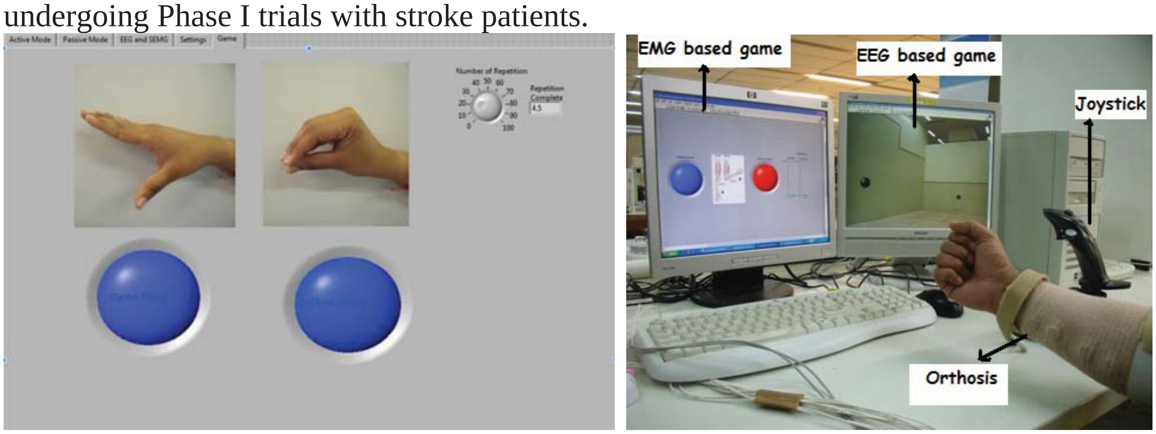

Figure 1. Gaming interface for EEG-SEMG Unified Platform, showing orthosis arm glove.

EFFECTS OF PRESENTATION OF JAPANESE MIMETIC WORDS ON THE MOTOR CONTROL OF UPPER LIMBS

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AIM: Verbal instructions are used at exercise education to explain about exercise techniques and to inspire motor imagery. It was clarified that presentation of verbs had a greater influence on the motor control of upper limbs than that of adjectives (Gentilucci 2003). It was also demonstrated that internal verbalization induced by verbs, but not by nouns, activated the motor-related area of the cerebral cortex (Grafton 1997). These results suggest that verbs and mimetic words work to give mental imagery of exercises. However, effects of mimetic words on kinematic aspects have never been studied. In this study, we investigated that effects mimetic word presentation exerted on the motor control of upper limbs.
METHODS: Subjects were 15 right-handed healthy adults (mean age, 30.8 years) who gave informed consent to participation in this experiment. This study was approved by the Ethics Committee of our institution. Subjects were required to reach the upper limb for and grasp an object on which words were printed. All these visually presented words were Japanese ones including “Hyoi”, “Gyu”, and “Don” as mimetic words and “Raise”, “Grasp”, and “Place” as verbs. Control word was a nonsense word “Aiu.” Mimetic words were presented along with verbs: “Grasp gyu” meaning “Grasp tightly” for example. Task 1 was to reach the upper arm out to grasp an object following mimetic word presentation, while task 2 was to implement the same arm movement following verb presentation. Analysis was made using a three-dimensional motion analysis device (MA-8000, ANIMA Co.) at a sampling frequency of 125 Hz. Parameters of concern were moving velocities as well as time-dependent displacement of the upper arm. The standard values for these parameters were those acquired at the time of reaching/grasping motor act without word presentation. Surface electromyography were recorded using the SX230 (Biometrics Ltd) with the surface electrode attached to the thenar muscles and integral values were obtained using the TRIAS system (DKH Co.). Inter-task comparisons were made with a one-way ANOVA as well as the Scheffe’s method. Mimetic words and verbs were compared in relation to each other by means of a paired t-test.
RESULTS: In the act of grasping, “Gyu”, “Don”, and “Grasp” stimulated significantly the muscular activity as compared to word non-presentation ($p<0.05$). In the act of putting down objects, “Hyoi” and “Raise” increased values of the height significantly ($p<0.05$). Practically none of the parameters showed significant differences between the mimetic word and verb groups. There were significant differences in none of the parameters between tasks imposed by nonsense word presentation and word non-presentation.
DISCUSSION: “Gyu” represents a Japanese mimetic word that expresses fastening an object tightly with all one’s might, so that this word affected the strength arrangement including muscular activity. Since “Don” expresses a situation where heavy objects collide with each other, this word influenced the temporal arrangement such as the velocity as well as the strength arrangements. “Hyoi” is a mimetic word representative of an easy small-scale up-and-down motion. This word therefore affected a parameter of the height of the spatial arrangement to the same extent that the height was changed when the verb “Raise” was presented. Mimetic words are expressed differently in different countries, but it is nevertheless possible that presentation of such words affects the motor control universally.

USING FINE-WIRE VERSUS SURFACE ELECTRODES TO QUANTIFY THE AMPLITUDE OF THE MYOELECTRIC SIGNAL OF HIP MUSCULATURE DURING THERAPEUTIC EXERCISE

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AIM: In order to assist in proper exercise prescription, recent studies have used electromyographic (EMG) methods to assess hip muscle recruitment patterns during various therapeutic exercises. However, most of these studies have used surface electrodes to quantify muscle activity, despite the probability of crosstalk from adjacent muscles. The purpose of this investigation was to determine the relationship between EMG amplitudes of selected hip muscles during therapeutic exercises using surface and fine-wire electrodes.
METHODS: Eleven healthy volunteers between the ages of 18 and 50 participated. Fine-wire electrodes were inserted into, and surface electrodes were attached to the skin overlying the tensor fascia lata (TFL), gluteus medius (GMED), gluteus maximus superior (SUP-GMAX) and inferior (INF-GMAX). Subjects performed maximum voluntary isometric contractions (MVICs) for each muscle. Raw EMG signals from both sets of electrodes were sampled simultaneously at 1560 Hz with a bandwidth of 35-750 Hz. Subjects then performed therapeutic exercises that included side-lying hip abduction (i.e., non weight-bearing) and a forward step-up (i.e., weight-bearing). Five repetitions of each exercise were performed, with a metronome pacing the movements. The mean root-mean-square (RMS) smoothing algorithm (75-ms window) was used and the EMG signals obtained during the exercises were normalized to those obtained during the MVICs. Pearson correlations were used to assess the relationship between the normalized signal amplitudes between the surface and fine-wire electrodes for each muscle in each exercise.
RESULTS: The correlations between the surface and fine-wire data for each muscle during sidelying hip abduction were -0.30 for the TFL, -0.12 for GMED, 0.66 for SUP-GMAX, and 0.38 for INF-GMAX. For the step-up exercise, the r values were 0.44 for the TFL, -0.40 for GMED, -0.06 for SUP-GMAX, and 0.26 for INF-GMAX. Only the correlation for SUP-GMAX was statistically significant ($p=0.03$).
CONCLUSION: In general, there was poor correlation between data obtained from fine-wire and surface electrodes. This finding suggests that studies that use different EMG methods to assess hip muscle function during rehabilitation exercises may arrive at different conclusions. The lack of correlation in normalized EMG amplitude between surface and fine-wire electrodes may be related to the sampling of different motor unit pools and/or muscle crosstalk.
ACKNOWLEDGMENT: Dr. Lucinda L. Baker for her consultation on EMG.

DOES CONSTRAINT-INDUCED MOVEMENT THERAPY EXACERBATE SPASTICITY IN STROKE HEMIPARESIS?

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AIM: Constraint-induced movement therapy (CI therapy) is a neurorehabilitation technique for upper limbs which are hemiplegic due to stroke and other brain injuries, developed by Wolf and Taub in the 1990s. Several randomized clinical trials have confirmed the efficacy of CI therapy for hemiparesis. However, some clinicians worry that CI therapy may exacerbate spasticity due to the excessive effort exerted while performing tasks for CI therapy. The aim of this study was to examine the influence of CI therapy on spasticity.
METHODS: Seventy-three patients underwent CI therapy for two weeks. Each patient received five hours of treatment daily for ten days (weekdays for two weeks). During the treatment, the unaffected upper extremity was restrained with a sling or a restraint glove. The Fugl-Meyer Assessment scale, modified Ashworth scale and other functional scales were assessed before and after treatment. Electrophysiological tests such as F wave and H reflex were performed in a few patients.
RESULTS: CI therapy significantly improved hand and arm function as assessed by the Fugl-Meyer Assessment ($p<0.01$), Wolf Motor Function Test ($p<0.01$) and Motor Activity Log ($p<0.05$) scales, but did not exacerbate spasticity, as assessed by the modified Ashworth scale. Some patients even exhibited a reduction in spasticity and related pain. Electrophysiological tests did not reveal any significant changes.
CONCLUSION: Our method for CI therapy was found to yield functional improvement in patients who are hemiplegic due to stroke. Despite the fact that patients exerted excessive effort to perform many of the tasks, CI therapy did not exacerbate spasticity following treatment, and in some cases, spasticity was even reduced following treatment.

Table 1: Changes in functional scales before and after CI therapy.

	Before	**After**
Fugl-Meyer Assessment	48.9 ± 9.6	54.0 ± 9.0*
Wolf Motor Function Test	51.8 ± 10.2	56.4 ± 10.0*
Motor Activity Log	1.4 ± 1.0	2.1 ± 1.0**
Modified Ashworth scale	1.43 ± 0.91	1.39 ± 0.83 (N.S.)

* p<0.01, **p<0.05

THE EFFECT OF LUMBOPELVIC POSTURE IN PELVIC FLOOR MUSCLE ACTIVATION IN CONTINENT WOMEN

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AIM: This study was undertaken to determine the effect of changing standing lumbopelvic posture on pelvic floor muscle (PFM) activation amplitude and timing and the resultant intra-vaginal pressure recorded during static and dynamic tasks.

METHODS: Sixteen nulliparous, continent women between the ages of 22 and 41 years performed five tasks [quiet standing, maximal effort cough, Valsalva manoeuvre, maximum voluntary contraction (MVC) of the PFMs, and a load-catching task performed with eyes open (BoxEO) and eyes closed (BoxEC)] in three different standing postures (normal lumbopelvic posture, hyperlordosis and hypolordosis). Electromyographic (EMG) data were recorded from the PFMs bilaterally using a Periform™ vaginal probe coupled to Delsys™ Bagnoli-8 EMG amplifiers. In separate trials, intra-vaginal pressures were obtained using a Peritron™ perineometer. Lumbopelvic angle was recorded simultaneously with EMG and intra-vaginal pressures using an Optotrak™ 3D motion analysis system to ensure that subjects maintained the required posture throughout the three trials of each task. All data were filtered using a moving 100ms RMS window and peak values were determined for each trial and task. Analyses of variance were performed on the peak PFM EMG, intra-vaginal pressure amplitudes, and lumbopelvic angles as well as activation onset data for the cough and load catching tasks.

RESULTS: There was significantly higher resting PFM activity in all postures in standing as compared to supine, and in the standing position, there was higher resting PFM activity in the hypolordotic posture as compared to the normal and hyperlordotic postures. During the MVC, cough, Valsalva, and load catching tasks, subjects generated significantly more PFM EMG activity when in their normal posture than when in hyper- or hypolordotic postures. Conversely, higher peak intra-vaginal pressures were generated in the hypolordotic posture for all tasks in all cases.

CONCLUSION: These results clearly indicate that changes in lumbopelvic posture influence both the contractility of the PFMs and the amount of intra-vaginal pressure generated during static postures and during dynamic tasks. Lumbopelvic posture does not, however, appear to have a significant effect on the timing of PFM activation during coughing or load catching tasks.

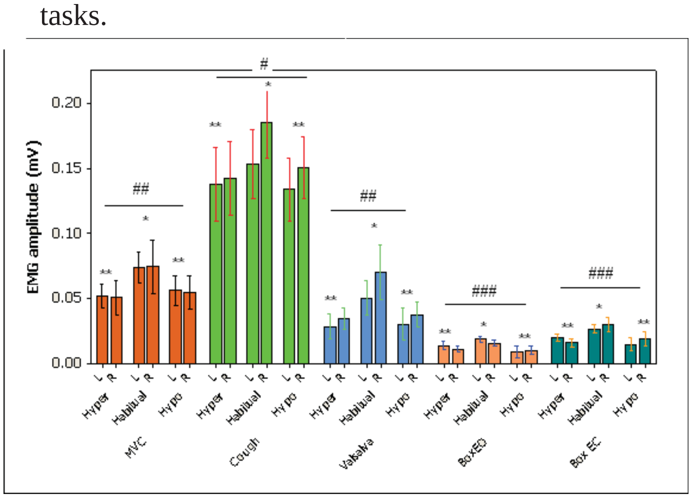

Figure 1: EMG amplitude recorded from the Pelvic floor muscles during different tasks performed in the different postures. *Hyper* =hyperlordosis, *Hypo= hypolordosis*. *L* = left PFMs, *R* =right PFMs. The between-task results are indicated by the # symbols. The cough task, labeled with # produced higher EMG activation than the tasks labeled with ## and the tasks labeled with ## produced higher EMG activation than the tasks labeled with ###. Within each task, the posture marked with * produced higher EMG activation than the postures marked with **.

SENSORIMOTOR TESTING FOR THE EARLY IDENTIFICATION OF INDIVIDUALS AT RISK OF DEVELOPING CARPAL TUNNEL SYNDROME: A CROSS SECTIONAL STUDY

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AIM: Carpal tunnel syndrome (CTS) is one of the most common injuries responsible for lost time claims in industry. The main purpose of this study was to determine whether sensorimotor abnormalities were detectable in asymptomatic individuals deemed at risk of developing CTS by virtue of work exposure.
METHODS: Participants were recruited into two strata: (1) asymptomatic individuals who were deemed to be at risk of developing CTS due to exposure to etiological risk factors and (2) asymptomatic individuals who were deemed to be at minimal risk of developing CTS based on non-exposure to risk factors. The outcome measures included two-point discrimination ability, pressure acuity, vibration sense, Purdue Pegboard Test performance and tracking error and tracking variance on a manual tracking task performed at two different speeds.
RESULTS: Seventeen individuals at risk of developing CTS participated as the study group, and 15 individuals with minimal risk participated as the control group. None of the measures of sensory perception were different between the groups. There was no difference in performance on the Purdue Pegbord Test between the groups. The error in the manual tracking task was significantly different between the groups both at fast (p=0.031) and slow (p=0.026) speeds, where the at-risk group demonstrated more error than the control group. During portions of the tracking task when the wrist was in full flexion, the at-risk group performed worse than the control group at fast speed (p =0.031) and there was a trend towards the at-risk group demonstrating more error at the slow speed (p = 0.077).
CONCLUSION: The manual tracking task may be able to identify, at an early stage, those individuals at risk of developing CTS but with no measurable sensorimotor impairment. A longitudinal study will follow to determine whether tracking performance predicts symptomatic CTS.
ACKNOWLEDGEMENT: Funding for this research was provided by the Center of Research Expertise for the Prevention of Musculoskeletal Disorders, University of Waterloo, Canada.

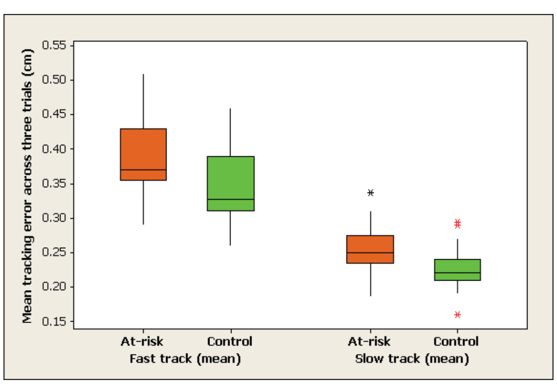

Figure 1: Comparison of Mean Tracking error (in cm) between the At-risk and control groups. In both the fast and slow tracking tasks the at-risk group generated significantly more tracking error than the control group

DIFFERENCES IN THE SUPPORT MOMENT BETWEEN FALLER AND NON-FALLER ELDERLY SUBJECTS DURING SIT TO STAND TEST.

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AIM: The frequently fall is a really problem in older people. Falls are a major cause of lose functional independence, institutionalization and death in elderly. The 35% of falls in elderly occurs in sit to stand transfer. In the process of treatment and prevention of falls is very important the identification of intrinsic factors related with high risk of frequently fall. The aim of this work was to determinate the possible differences of the support moment of lower limb in fallers and non-fallers elderly people during the rise from a chair.
METHODS: Thirty elderly subjects with history of frequently falls and thirty elderly subjects without antecedents of frequently falls were evaluated using a motion analysis system during sit to stand performance. The support moments in sagital plane were calculated with inverse dynamics.
RESULTS: The results indicate that faller subjects had smaller peak of support moment than non fallers subjects (p=0.001). Whereas the joint moments doesn't show significantly differences among both groups (p>0.05). See figure 1.
CONCLUSION: The motor strategy of joint moments did not difference between faller and non-faller subjects. However the results indicate that fallers, would have a smaller capacity to generate support moment in comparison with the subjects without history of frequently falls. These discoveries could indicate that the risk of frequently fall would be related with the deterioration in the capacity of integration of joints moments to generate support of lower limb in faller subjects.

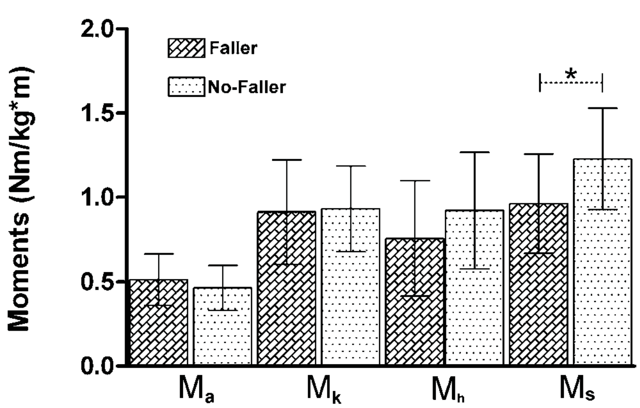

Figure 1: Support and joint moments in faller and no-faller subjects. Ma: ankle moment. Mk: knee moment, Mh: hip moment and Ms: support moment.*p=0.001.

DISCRIMINATE ANALYSIS BETWEEN SUBJECTS WITH AND WITHOUT HISTORY OF FREQUENT FALLS USING BIOMECHANICS PARAMETERS

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AIM: The frequent falls in older people is a real problem in our society. In the prevention falls process is need new information to create or to improve the tools for prediction falls. The objective of this work was discriminate between older subjects with and without using biomechanics parameters measures during performing a function task.
METHODS: In thirty older subjects with a history of frequent falls (≥ two falls in the last year) and thirty older subjects without a history of frequent falls was evaluated biomechanics parameters during performing the sit to stand test (velocity of center of mass, anterior trunk flexion, joint and support torque and execution timed). A discriminate analysis was performed using the biomechanics parameters.
RESULTS: The discrimination among subject with and without history of frequent falls was statistically significant (E-value: 1.18; Lamda Wilks: 0.46; Chi Square : 41.56: Grades of freedom: 9; p=0.000004). The level of sensibility and specificity was of 87 and 83% , respectively. The distribution of discriminate scores for both groups is show in the figure 1.
CONCLUSION: The biomechanics parameters evaluated during sit to stand performance were useful to discriminate among faller and non faller older people.

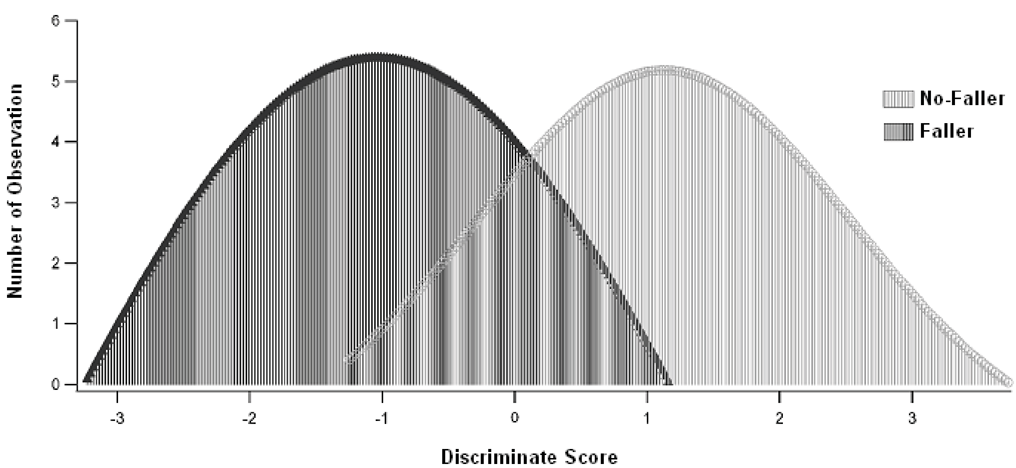

Figure 1: Distribution of discriminate scores calculated with discriminate equation built biomechanics parameters evaluated during sit to stand transfer.

CONTROL OF POSITION OF CENTER OF MASS: POWERED WALKAROUND®

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AIM: We designed the powered walking assistance (Walkaround®) that controls the orientation of the trunk in vertical direction during the walking (left panel), and controls the position of the belt within the moving frame by three pneumatic actuators acting over adjustable elastic suspensors. The actuation of the belt within the frame was anticipated to follow the characteristic path found in healthy subjects when walking unrestricted at low pace (right, top panels).

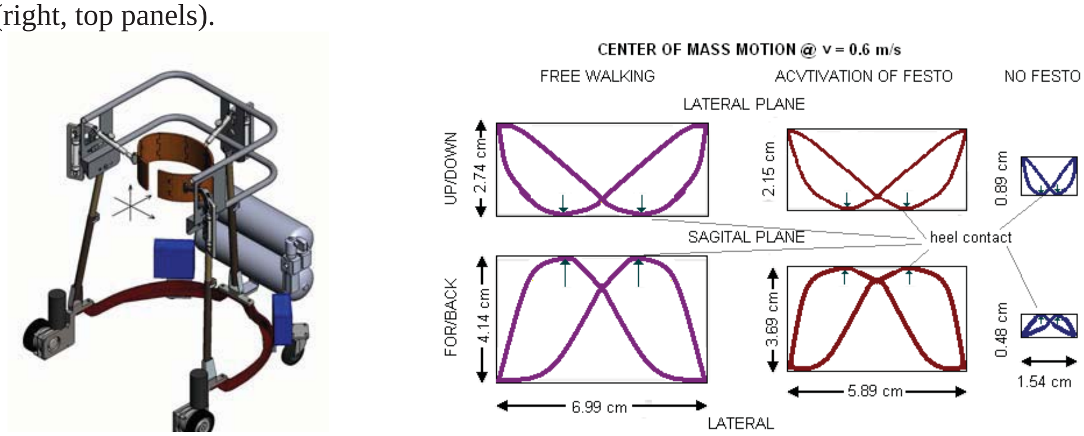

Figure 1: Powered walking frame with pneumatic actuators controlling the position of the trunk (left panel). The trajectory of the center of mass with respect the center of the frame in the lateral and sagittal planes for "free" walking, with and without actuation.

METHODS: The actuation is realized with FESTO artificial muscles. The operation is controlled by a microcontroller 18F452L from Microchip©. The lengths sensors signals provide necessary information for control of valves, that is, lengths of the artificial muscles. The force sensors mounted in the frame in series with the artificial muscles provide signals that are used as the safety feature of the system. The desired butterfly patterns are the paths of the center of mass extracted from the literature data for the speed of walking v = 0.6 m/s. The system supports the walking at speeds between 0.2 and 1.5 m/s.
RESULTS: The operation of the system was tested in three hemiplegic subjects. The paths of the center of mass when actuated and when not actuated (right panels) show the effect of artificial muscles. The raising of the center of mass for about 3.5 cm contributed to the increased symmetry (index of symmetry SI=0.07 / actuated, compared to SI =0.23 / no actuation). The ratio of double support phase *vs.* the stride cycle reached 0.88±0.09 compared to free walking. The externally controlled motion of the center of mass contributed to the statement from all three subjects: "I felt safer when walking".
CONCLUSION: Powered walking assist with controlled center of mass position could be a valuable tool for the training of hemiplegic subjects since it provides natural-like gait pattern.
ACKNOWLEDGEMENT: This work was partly supported by the Ministry of Science and Technology of Serbia, Belgrade

ON THE EFFECTS OF VIBRATION TRAINING ON MUSCLE FATIGUE

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AIM: Vibration training is reported to be a valid option for muscle training, capable of enhancing muscle force through increased neuromuscular activation of target muscles. A thorough characterization of the electrophysiological mechanisms induced by vibration stimulation protocols is however lacking. In this context, the aim of this study was to assess the effects of different vibration stimulation protocols on fatigue.
METHODS: A dedicated electromechanical setup was built capable of applying vibratory stimulation during an arm flexion task at a constant level of force. An accurate calibration of the setup and a full control on the force applied to the muscle was obtained by use of strain gauges. 10 young males (mean age = 25.5 ± 4) performed four randomized sustained (1 min) contractions of the right biceps brachii with a constant tension corresponding to 80% of their maximum voluntary contraction (MVC) while receiving a superimposed vibration at 0 (no vibration), 20, 30, and 40 Hz. The biceps surface electromyogram (EMG) was measured during each experimental trial. The evolution of the EMG mean frequency during each contraction was estimated by EMG time-frequency analysis (short-time Fourier transform). Muscle fatiguing rate was estimated as the angular coefficient (Hz/s) of the regression line fitting the EMG mean frequency during the experimental trials (Fig. 1). Before and after each trial, the volunteers performed an MVC of the biceps brachii. The measured force decay was considered as an additional indicator of muscle fatigue.
RESULTS: Both the EMG and MVC measurements showed a greater degree of fatigue with vibration (Table 1), with the most relevant effects observed at 30 and 40 Hz.
CONCLUSION: We investigated for the first time the fatiguing effect of vibration exercise superimposed to a high level of muscle tension at different frequencies. The results suggest vibration training to be more fatiguing than training at constant muscle tension, supporting the idea that such stimulation determines higher neuromuscular demands. Future research will include the assessment of fatigue by action-potential conduction-velocity analysis.

Table 1: Measured fatigue estimators.

Test	EMG mean frequency decay (Hz/s)	Maximal isometric force decay (%)
No vibration	-0.46 ± 0.33	21.8% ± 13.5%
20 Hz	-0.47 ± 0.39	22.6% ± 12.5%
30 Hz	-0.52 ± 0.23	22.6% ± 12.8%
40 Hz	-0.51 ± 0.25	24.1% ± 13.6%

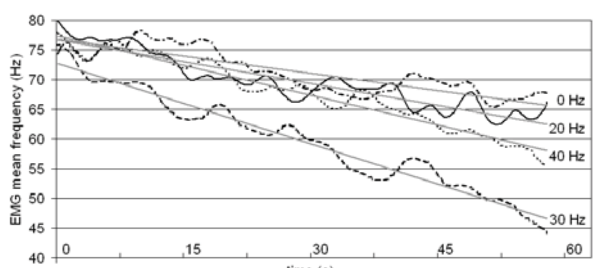

Figure 1: EMG mean frequency with regression line in four trials from 0 to 40 Hz vibration.

EFFECT OF THE KINETIC ACUPUNCTURE INCLUDING HUALONG MANEUVER ON NECK PAIN DISORDERS WITH VERTEBRAL MISALIGNMENT/SUBLUXATION

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AIM*:* This work was based on a comparative study aiming to evaluate the inclusion of an anti-thrust procedure known as Hualong maneuver (HM)[1] in the Kinetic acupuncture(KA)[2] method to treat neck pain disorders with vertebral misalignment/subluxation(VMS).[1] *Design:* A prospective, comparative clinical trial. *Setting:* Acupuncture and Rehabilitation Department. *Background:* In general, VMS is treated by manipulative techniques with thrust maneuver for spinal adjustment in high velocity and low amplitude movements. However, some authors suggest that if this type of manipulations is not performed accurately, it may result in uncommon side effects (local discomfort, pain or spasms for a few days, mild headache or fatigue), or even serious complications, including bone fracture or dislocation and stroke.[3,4] The HM is an anti-thrust mobilization method achieved by a gentle wave motion, at slow pace and without resistance, which safer comparing to other manipulations with thrust. Since it can relieve the neuromusculoskeletal components[5], smoothly, and thus facilitate the mobility of the upper and lower parts of the vertebral column. This procedure can be performed in a single movement or in sequence, depending on the adaptability "kinetic moment"[1] of each patient. It was described and developed by the authors since 2000, and applied in the beginning of the 2nd stage of KA therapy to reinforce the analgesic and muscular relaxation effects induced from the first stage by acupuncture.
METHODS: *Subjects:* Thirty-seven patients with neck pain disorders. Interventions: patients were allocated into two groups; Group-1 received KA (acupuncture, HM and physiotherapy). Group-2 received acupuncture alone. Both groups were treated in 10 sessions over a period of 10 weeks with one or two sessions weekly. *Outcome assessment:* All patients had completed the protocols and were assessed using a visual analogue scale for pain intensity and muscle tension, the Neck Disability Index: Brazilian Portuguese version for functional disability, and the Cranio-Cervical Flexion Test for isometric neck muscle strength[6]; in the periods before treatment (baseline), after 10 weeks of treatment, and after 6 months of follow-up.
RESULTS: All groups (intragroups and intergroups) showed significant improvement (p<0.001) in these parameters after 10 weeks of treatment and after 6 months of follow-up.
CONCLUSION: The data suggested that the inclusion of HM in KA treatment may facilitate and/or enhance the therapeutic effects rehabilitation of patients with neck pain and others musculoskeletal disorders due to VMS.

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ABDOMINAL MUSCULAR RESPONSE COMPARING TWO CONVENTIONAL EXERCISES AND FOUR MOTOR GAMES

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AIM: The purpose of this study was to compare the EMG amplitude of the abdominal muscles in 2 popular trunk exercises and 4 motor games used in Physical Education in Spain.
METHODS: Twenty recreationally trained volunteers were recruited from the university population. After warming-up, participants randomly performed the exercises and games. The trunk isometric exercises were the “curl-up” or “crunch” and the “side bridge” or “side support”, which are broadly used given that they challenge the abdominal muscles while imposing minimal load penalties to the spine. The motor games were the “wheelbarrow race” (keeping the spine in a neutral position), the “hula-hoop”, the “balancing man” (i.e. a subject is standing and he/she is rocked laterally imitating a roly-poly movement by 2 researchers) and the “chicken fight” (i.e. a subject laterally pushes against an opponent (“chicken”) while kneeling with his/her arms curled-up imitating wings). Surface EMG (Muscle Tester ME6000, Mega Electronics Ltd.) was collected from the right rectus abdominis (RA), external oblique (EO), internal oblique (IO) and erector spinae at L3 level (ES). The EMG signals were full wave rectified, averaged every 0.1 s, and then normalized to maximal voluntary isometric contraction (MVC) amplitudes. Statistical analyses were performed using repeated-measures ANOVA.
RESULTS: As shown in table 1, the highest EMG amplitudes of RA were found during the wheelbarrow race ($p < 0.05$), followed by the crunch and the hula-hoop. For the IO, the wheelbarrow race and the chicken fight produced higher EMG amplitudes than the two abdominal exercises ($p < 0.05$). For the EO, the wheelbarrow race and the side bridge generated the highest activation levels. For most of the muscles, the lowest EMG amplitudes were found during the balancing man and the crunch exercise.
CONCLUSION: The wheelbarrow race, the chicken fight and the hula-hoop generated levels of muscular activation that were similar to, or higher than, those generated during the execution of conventional abdominal exercises. Therefore, some motor games could be considered fun and effective in strengthening the abdominal muscles.
ACKNOWLEDGEMENT: This study was made possible by financial support from: Universidad Miguel Hernández de Elche (Bancaja-UMH 2009), Spain; Universidad Católica San Antonio de Murcia (PMAFI-PI-02/1C/04), Spain.

Table 1: Averages and standard deviations of the normalized EMG amplitudes (% MVC).

Tasks	RA	EO	IO	ES
Crunch	29.3 ± 12.5	8.8 ± 8.6	23.8 ± 10.1	11.3 ± 8.9
Side bridge	16.8 ± 9.6	62.2 ± 30.9	26.5 ± 17.6	20.3 ± 9.6
Wheelbarrow race	44.9 ± 21.8	72.1 ± 18.5	65.7 ± 32.6	20.6 ± 14.7
Hula-hoop	25.6 ± 17.5	33.4 ± 13.4	25.2 ± 13.5	23.2 ± 14.7
Chicken Fight	10.9 ± 13.1	45.8 ± 27.8	48.1 ± 22.4	25.5 ± 10.2
Balancing man	7.8 ± 5.8	19.4 ± 7.5	16.8 ± 13.9	11.6 ± 5.2

POINTING TO DOUBLE STEP VISUAL STIMULI: MUSCULAR SYNERGIES OBSERVED DURING MOTOR CORRECTIONS.

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AIM: The aim of this experiment was to determine how muscle activities were coordinated after a target jump to modify the initial motor plan and to keep the goal task safe. Is the Central Nervous System (CNS) able to generate correlated muscular activations, i.e. generate muscular synergies, during perturbed movements? Are these eventual muscular synergies similar to those used during the analogous goal oriented movement in an unperturbed condition?
METHODS To answer these questions, eight healthy participants [all males, 23 – 36 years old, 70 ± 6 kg, 1.76 ± 0.02 m] were required to realize a complex pointing movement involving the whole body, from a sitting to a standing position to a target which unexpectedly jumped from a low to a higher location. Surface electrical activities were recorded (SMART-BTS, Milan, Italy, 960 Hz frequency) on the right side of the subjects in sixteen muscles, namely the tibialis anterior, soleus, rectus femoris, vastus lateralis and the biceps femoris at the leg level, the rectus abdominis, erector spinae between L3 and L5, erector spinae between D11 and L1, pectoralis, latissimums dorsi, and the trapezoid at the trunk level, the deltoïdus anterior, deltoïdus posterior, biceps brachii, triceps brachii and the brachio radialis at the arm level. Raw EMG signals were first bandpass filtered between 20 and 400Hz, then full-wave rectified and filtered using an averaging moving-window algorithm (window size: 25 ms). The time to correction, i.e. the delay between the target jump and the beginning of the motor correction, were computed for each recorded muscle.
RESULTS: Electromyographic investigations on the sixteen muscles showed fourteen significant correlations between the time to correction of ten muscles at various locations in the arm, the trunk and the leg (fig 1.A). Importantly, these correlations were not dependant of their level in the anatomical plant or of their time to correction occurrences. For instance, the time to motor correction of the tibialis anterior (in the leg) was strongly correlated with the one of the trapezoid (in the neck) (r = 0.97) or the one of the biceps brachii (r=0.83) (fig 1.B).
CONCLUSION: Our results clearly showed that muscular synergies could be used in perturbed movement and that these muscular synergies were strongly different between perturbed and unperturbed movement for a similar goal oriented task.

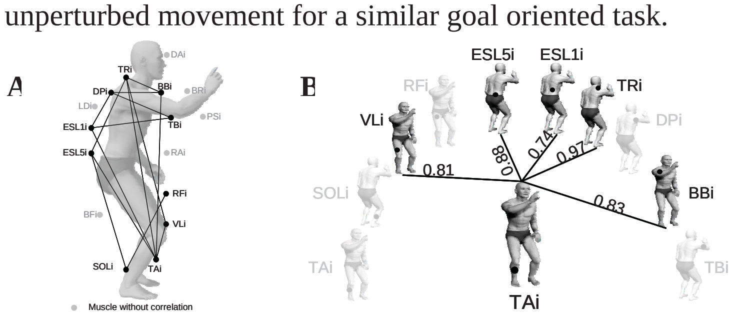

Figure 1: A. Significant correlations of the time to motor correction for the eight subjects and the sixteen recording muscles are represented on one single body.**B.** For the tibialis anterior, significant correlations are represented by a link between each pairs of correlated muscles involving the tibialis anterior

CENTRAL OR PERIPHERAL MUSCLE FATIGUE IN CANCER SURVIVORS?

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AIM: The aim of the study is to analyze if central activation failure (CAF), an indicator of central muscle fatigue, and/or muscle fibre conduction velocity (MFCV), an indicator of peripheral muscle fatigue, can be used as a biological marker for postcancer fatigue.
METHODS: Five severely fatigued and three non-fatigued male cancer survivors were included. Patients had completed treatment of a malignant, solid tumor minimal one year earlier and had no evidence of disease recurrence. Patients with a co-morbidity that could explain fatigue were excluded. Fatigue severity was measured by the fatigue severity subscale of the Checklist Individual Strength. CAF was measured during a two min. sustained maximal voluntary contraction (MVC) of the biceps brachii muscle, based on a twitch interpolation technique. Electrical endplate stimulation over the motor points of the biceps brachii muscle was applied before, during, and after sustained MVC. Force and MFCV were registered, the latter using surface electromyography (sEMG).
RESULTS: Data on voluntary force (Figure 1A) and CAF (Figure 1B) were available for five fatigued and three non-fatigued patients, and data on MFCV (Figure 1C) were available for three fatigued and two non-fatigued patients. No significantly different values were found between severely fatigued and non-fatigued participants in voluntary force, MFCV, and CAF during two min. sustained MVC.
CONCLUSION: In neurophysiology, fatigue is defined as loss of voluntary force producing capacity during exercise. For patients with the chronic fatigue syndrome (CFS), a central neurophysiological component, CAF, has already been identified (Schillings *et al* 2004). To our knowledge, we are the first to report on neurophysiological fatigue in postcancer patients. No differences in voluntary force, MFCV, and CAF were observed between fatigued and non-fatigued patients. Therefore, based on these preliminary data, measurements of voluntary force, MFCV, and CAF cannot be used as biological marker of postcancer fatigue. However, more subjects need to be included in our study to corroborate our data.
ACKNOWLEDGEMENT: Dutch Cancer Society (KUN 2008-4002) for funding the study.

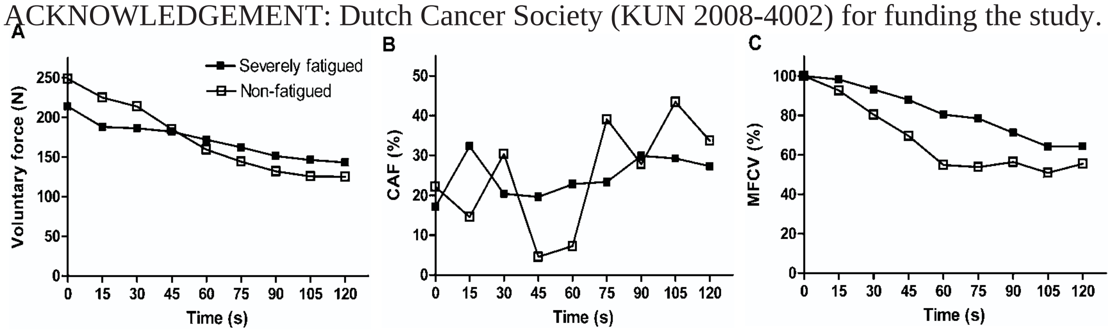

Figure 1: Data on voluntary force (A) and CAF (B) of five severely fatigued and three non-fatigued cancer survivors, and MFCV (C) of three severely fatigued and two non-fatigued cancer survivors, during 2-min sustained MVC. Mean values are presented. No significantly different values were found between both groups.

FUNCTIONS OF TOES AT LEVEL WALKING

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AIM: When the human is walking, the force and the moment act on planta pedis and the human keeps the balance by catching the ground with toes. The force acting on planta pedis is the important index for the evaluation of a standing balance and the gait disturbance. We focused on the interaction between planta pedis and the floor, and measured the force to act on the planta pedis on the ground plane in 3 component forces. The purpose of this study is to analyze the functions of the toes at the level walking, using 3-axis-force-sensors.
METHODS: The subjects were four normal adult males without the disease of the orthopedics, and their averaged age was 21.0±0.8. The subject put on the insole, which buried six 3-axis-force-sensors in the left foot. Figure 1 shows the position of the sensors. The subject put on a sheet of rubber of the same thickness to the right leg so that the leg length difference does not occur. The output of the sensors were converted by AD converter at sampling frequency 500Hz and were stored in a data logger. The subject performs level walking for 30 seconds with 100 steps per minute by hearing the sound of a metronome. The subject practiced level walking with 100 steps per minute before the measurement. We extracted the data from 10 sec. to 20 sec. from the start of walking. The ten-sec-length data contained the data of eight steps of walking. Moreover, we normalized the 10-sec-length data in walking cycle, averaged them with eight steps, and analyzed the results.
RESULTS: Figure 2 shows the results of 3-axis-force. The period from the foot flat to heel off, the force at the calcaneal region center shows a component force to the front direction and the force at the microdactyly ball, microdactyly, and the first toe show a component force to the posterior direction.
CONCLUSION: In this study, we attached six 3-axis-force-sensors to planta pedis and measured the function of the toe in the level walking. As a result, it became clear that the toes catch the ground at the time of walking.

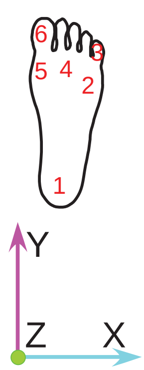

Figure 1: The position of sensors

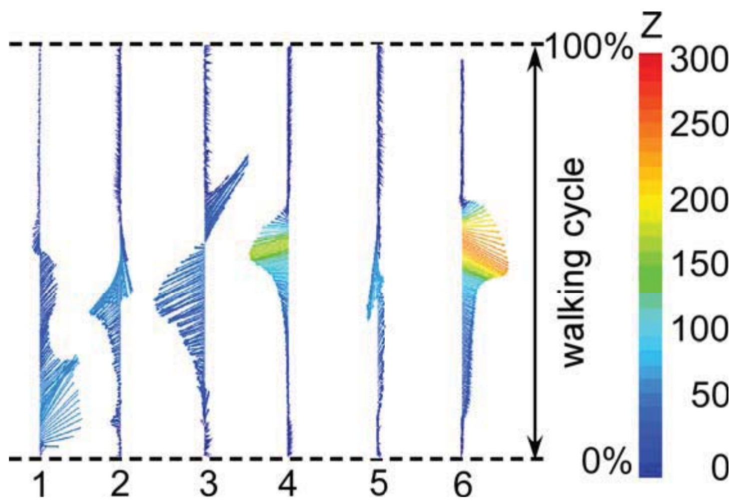

Figure 2: The results of 3-component-forces at each position. The number indicates the position of the sensor shown in Figure 1.

DEVELOPMENT OF A MULTIDEVICE ROBOT-AIDED REHABILITATION ARCHITECTURE

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AIM: This work presents a multidevice architecture for robot-aided rehabilitation able to provide progressive assistance regulation. It implements the recently proposed techniques based on the motor learning phenomenon in relation to activities that are repetitive, task oriented and attention-demanding. This technique can improve the patient's motor performance, shorten the rehabilitation time and provide objective parameters for patient evaluation.
METHODS: The architecture consists of a hardware-software platform able to interface different haptic devices with two and three DoF. It is implemented using the open-source platform H3D API which provides graphic representation of the assigned motor tasks in a 2D/3D graphic environment, and generates the appropriate haptic effects. The system includes a specific module for the evaluation of the subject's performance during task execution (quantitative evaluation metrics). In addition there is progressive guidance for training in the virtual environments. The progressive guidance scheme adjusts its control gains based on subject performance. If the performance increases the difficulty level of the task is also increased; conversely if the performance decreases the task is made easier.
RESULTS: The software (called Haptic Manager) allows to select the device and implement specific training strategies. The haptic interface provides different types of tactile feedback such as object interaction, trajectory tracking and reaching in a force field. At present it supports the "Braccio di Ferro" and Falcon devices and includes the evaluation metrics measuring the patient's performance obtained during the requested motor task.
CONCLUSION: The availability of this type of architecture should allow to speed-up the learning process of different motor tasks so facilitating the treatment of different pathologic conditions of the neuromuscular system. The inclusion of the progressive guidance regulation should promote patient motivation during the whole course of treatment.
ACKNOWLEDGEMENT: This work was supported by the EU grant FP/-ICT-271724 HUMOUR.

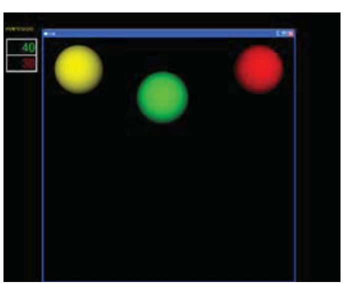

Figure 1: Exercise display

Figure 2: Haptic Manager User-Interface

A MULTICHANNEL SEMG METHOD FOR MYOELECTRIC CONTROL OF A FOREARM PROSTHESIS

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AIM: Myoelectric prostheses are often not used by their owners [1]. This is mainly due to the limited functional possibilities, which are hampered by the limited number of degrees of freedom (DOFs) that can be controlled. A potential method to increase the number of DOFs at the sensing side is the use of multichannel surface electromyography (sEMG) to distinguish between different contractions. The aim of this study was to investigate if it is possible to distinguish eight natural isometric contractions of wrist and hand with a classifier based on spatial information obtained by multiple electrodes placed on the forearm.
METHODS: A grid of forty surface electrodes (4x10) was placed on the forearms of ten able-bodied subjects (Figure 1) and a grid of thirty electrodes (3x10) on the short stump (10 cm) of one patient with a congenital reduction defect. Signals of eight different isometric contractions (Table 1) were collected. Each contraction lasted five seconds and was repeated three times. Root mean squared values were calculated for twelve periods of 200 ms that were selected from each repetition. Datasets were classified offline by means of an individually trained nearest neighbour classifier. The performance of the classifier was tested by cross-validation: the dataset was randomly split into a training set and a test set with a ratio of 4:1. This procedure was repeated five times. The accuracy of the classifier was calculated as the mean percentage of correctly classified contractions of all data. Thereafter, it was investigated whether reducing the number of electrodes was possible by training and testing with an equally distributed selection of both half and one quarter of the original electrode grid.
RESULTS: The average accuracy of the offline classification was 99.9% for able-bodied subjects (Table 1) and 99.6% for the patient. The mean performance for all able-bodied subjects decreased with 0.05% for 20 electrodes and with 0.12% for 10 electrodes. For the patient, the accuracy decreased with 0.08% for 15 electrodes and with 0.36% for 8 electrodes.
CONCLUSION: The results are very promising for the development of a next generation myoelectric prostheses with an increased number of controllable DOFs. Further validation with forearm-amputation patients during functional tasks and random ordered contractions is necessary. In addition, simultaneous control of different movements, proportional control and real-time classification must be investigated.

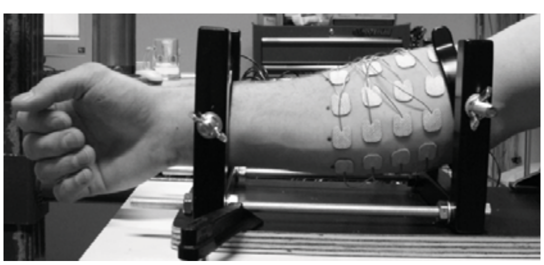

Figure 1: Electrode placement (able-bodied)

Table 1: Confusion matrix (able-bodied)

Input \ *Output*	FF	FE	P	S	AB	AD	WE	WF
Finger flexion	**99.96**	0.01		0.01		0.01	0.01	
Finger extension	0.01	**99.91**	0.01		0.01			0.06
Pronation			**99.96**					0.04
Supination	0.01	0.01		**99.88**	0.03		0.06	0.01
Wrist abduction			0.02	0.02	**99.93**	0.02	0.03	
Wrist adduction			0.01			**99.97**	0.01	
Wrist extension	0.03	0.01	0.02	0.11	0.01		**99.82**	
Wrist flexion		0.03	0.04				0.01	**99.92**

[1] Biddiss, E.A. and T.T Chau (2007). *Prosthet Orthot Int.*, 31(3), 236-57.

THE RELATIONSHIP BETWEEN MYOELECTRIC ACTIVITY AND OXYGENATION DURING ISOMETRIC CONTRACTIONS IN THE FOREARM AND SHOULDER MUSCLES OF HEALTHY MALES AND FEMALES

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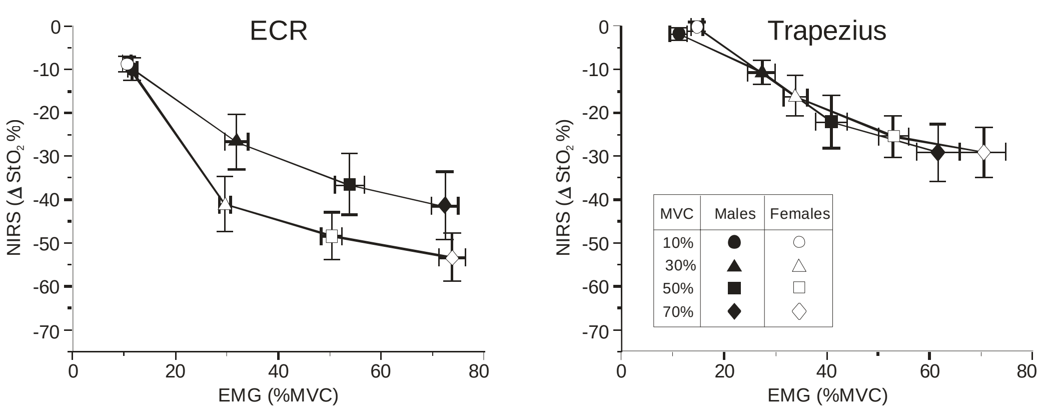
AIM: Combining measurements of myoelectric activity and oxygenation can provide important insight into the functional and metabolic study of muscle tissue. The aim is to determine the relation between electromyographic (EMG) amplitude (RMS, root mean square) and oxygen saturation (StO_2%, derived with near infrared spectroscopy, NIRS) in the trapezius and extensor carpi radialis (ECR) muscles of healthy males and females. These muscles were of interest because they are prone to work-related pain.
METHODS: Thirteen males (26 ± 5 yrs) and fifteen females (26 ± 5 yrs) were equipped with probes for surface EMG and NIRS over the right forearm ECR and shoulder trapezius muscles. After determining the maximal voluntary contraction (MVC) force, isometric contractions of 10%, 30%, 50% and 70% MVC were held for 20 s each. RMS was calculated as a percentage of maximum and for NIRS data the change in StO_2% from baseline (ΔStO_2%) was calculated. Mean (± SE) ΔStO_2% and RMS over force for males and females are shown below. For each subject a slope value (k) and a correlation coefficient (R) between ΔStO_2% and RMS were calculated and mean value differences between genders were tested with t-tests.
RESULTS: For the ECR, the mean slope for females (k=-0.67) tended to be steeper than for males (k=-0.48), (p=0.10). Females also tended to present a stronger correlation (R=-0.87) than males (R=-0.60), (p=0.06). For the trapezius, slopes and correlations for males (k=-0.60, R=-0.71) and females (k=-0.56, R=-0.77) were nearly the same



CONCLUSION: Our results indicate a gender specific pattern for the relation between StO_2% and RMS for the ECR, but not for the trapezius (also implying muscle specificity). These data may augment future investigation of the poorly understood mechanisms behind work-related muscle pain and why females are more at risk than males.
Key words: EMG; NIRS; muscle oxygenation; gender

IRREGULAR HEAD MOVEMENT PATTERNS IN WHIPLASH PATIENTS DURING A TRAJECTORY TASK.

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AIMS: Patients with whiplash associated disorders (WAD) have shown less accuracy in trajectory head motion compared to asymptomatic controls, which comply with clinical observations. The aim of this study was to investigate whether a trajectory head movement task can differ between WAD patients, chronic non-traumatic neck pain (CNP) patients and asymptomatic controls in terms of movement smoothness. The contributions of neck pain and dizziness to movement smoothness were also investigated.
METHODS: Study groups included subjects with WAD (n=35) with persistent neck pain after a car accident, CNP (n=45), and asymptomatic controls (n=48). Movement smoothness was studied with a “figure-of-eight” trajectory task; a laser pointer was attached to the head and the subjects asked to trace a figure of eight displayed on the wall at three different paces (slow, moderate and fast) from an unsupported standing position. Head motion was recorded using a 3D Fastrak device. The motion signal was decomposed into 1 Hz frequency bands and angular velocity (°/sec) within each frequency band was calculated.
RESULTS: Significantly higher angular RMS velocity was found in the WAD group compared to the two other groups for the slow paced test (3-4 Hz and 4-5 Hz frequency bands) and the moderate paced test (3-4 Hz frequency band) indicating irregular and uncoordinated movements. High levels of angular RMS velocity were associated with pain and dizziness, but only with severe symptom levels. No significant group differences were revealed for the fast paced test.
CONCLUSION: In this study, lack of movement smoothness was found in the WAD group only, indicating that some motor control deficits seem to particularly associate with a traumatic onset of neck pain. Irregular head movement patterns were also associated with high levels of neck pain intensity and dizziness, but not with low and moderate levels. The “movement irregularities” were found within frequency levels observable to clinicians.
ACKNOWLEDGEMENT: The project received financial support from the Norwegian Fund for Post-Graduate Training in Physiotherapy.

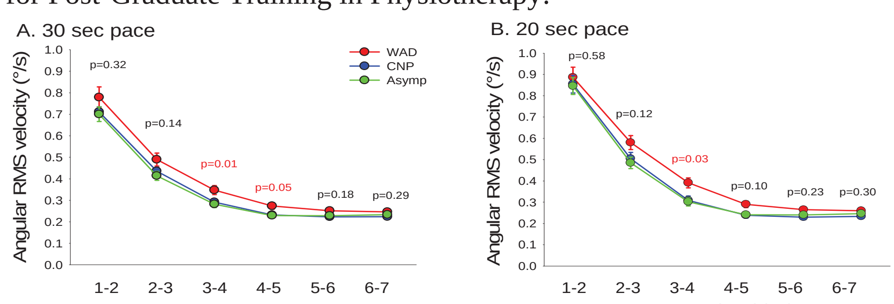

Figure 1: Head movement signals presented as mean (SE) angular RMS velocity (°/s) of 1 Hz frequency bands (1-2 Hz, …., 6-7 Hz) for the slow (A) medium (B) paces. The basic figure-of-eight movement signal is < 1 Hz and thus eliminated from the results. Statistically significant group differences (p≤0.05) are typed in red.

GAIT ADJUSTMENTS DURING THE APPROACH TO A RAISED SURFACE

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AIM: The task of climbing a curb after crossing a street represents a challenge to elderly people may imply an increased risk of falling. Relevant anticipatory strategies are necessary in this task. The aim of this study was therefore to investigate whether the motor planning and gait adjustments in response to the negotiation of a raised surface are different between elderly and young people.
METHODS: Fourteen young subjects and eleven healthy community-dwelling elderly with no recent history of falling participated in the study. Gait characteristics were evaluated during the approach to a 15 cm high platform which had to be negotiated. In a second set of trials the participants were additionally challenged by an arithmetic dual task. Gait parameters were measured by an electronic mat (GaitRITE). Gait velocity for each step could be calculated from step length and step time. Individual step velocity was evaluated in relation to step velocity measured during unperturbed gait with no obstacles.
RESULTS: In both groups the gait pattern was modified as to adjust for the optimal foot placement of the last step in relation to the edge of the platform. During the approach to the platform the young participants had a tendency to increase their step length and step velocity while the elderly shortened the step length and slowed the velocity (fig.1). Both groups walked slower during dual task, but the tendency to an age related difference in the motor planning remained.
CONCLUSION: When approaching a raised surface elderly people have a tendency to choose a different anticipatory strategy than the young. The elderly decrease the walking speed as opposed to the young. This may be an adaptation to a more safe strategy, but on the expense of momentum and efficiency of the climb onto the raised surface.
ACKNOWLEDGEMENT: Equipment was sponsored by Toyota Foundation, Denmark.

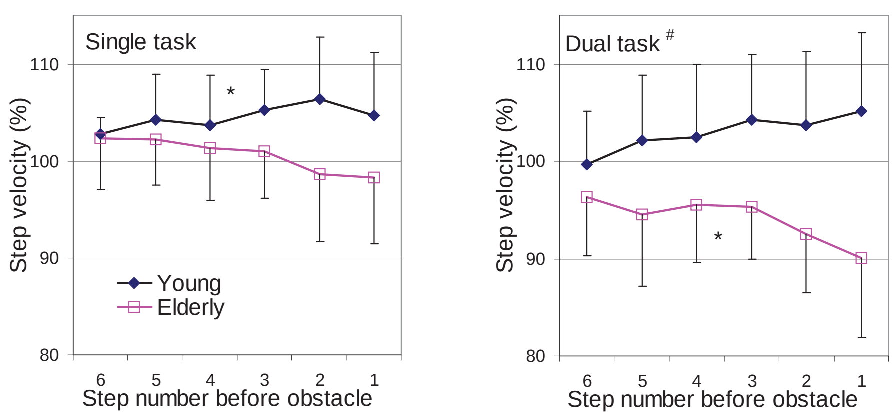

Figure 1: Different gait adjustment strategies for young and elderly.
* Difference from steady walking (100%); p<0.05; # Dual task effect; p<0.05

PAST, PRESENT AND FUTURE OF HDsEMG

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AIM: Surface electromyography (sEMG) is still often intended as the interpretation of the signal obtained from a pair of electrodes applied on the skin above a muscle. This is just a single spatial sample of the superficial distribution of potential that is varying in time and space, not dissimilar by the colour of a single pixel of a picture evolving in time. The EMG picture is the 2-D map of the potential read using an array of NxM electrodes (NxM = 64 to 512). The aim of this contribution is to illustrate the current and future fabrication techniques and applications of these arrays that provide High Density surface EMG (HDsEMG).

METHODS: Current arrays are fabricated by means of a) silver-plated eyelets applied on a piece of cloth, b) flexible printed circuits on mylar or kapton, c) screen printing on paper or mylar, d) telescopic pins on a rigid support, e) short pins incorporated in a flexible rubber support. Interelectrode distances range from 2.5mm to 10mm. The arrays can be fixed with double adhesive thin foam or elastic Velcro straps. Connections of the electrodes to a multiple cable can be done by means of printed circuit or screen printed conductive lines, whose minimal width is ~0.2 mm and separation is ~0.2 mm, or by embroidered insulated metal wires or conductive threads. Skin contact is obtained by gel introduced into the eyelets or spread into the cavities of the foam through a mask before application of the array to the skin. The current techniques are limited mostly to isometric conditions. New techniques under development consist of a) multiple layer screen printing, b) ink-jet printing of electrode surfaces and conductive lines, including multilayer technology to allow line crossings. Line width and spacing of <0.1 mm are expected. Pre-gelled disposable arrays are being investigated to avoid bad contacts with the skin or short circuits between electrodes.

Expected future arrays will incorporate integrated electronic circuits required for signal amplification, conditioning and A/D conversion. Only a few wires would then be required for the connection to a PC through a USB-2, USB-3 or Ethernet port. Washable and reusable elastic sleeves with hundreds of electrodes will monitor the entire surface of a body segment, possibly through a wideband wireless system. 2-D interpolation techniques and reconstruction of a limited number of “bad” channels (due to poor contacts or short circuits) will provide a “clean” map with an increased number of pixels.

RESULTS: Image processing can be applied to HDsEMG to obtain: a) orientation and length of muscle fibers and location of motor unit (MU) innervation zones, that is a form of “non-invasive anatomy” of the most superficial muscle layers, b) average muscle fiber (as well as single motor unit) conduction velocity estimated with smaller errors than a linear electrode array allows today, c) decomposition of the signal into the constituent MU action potential trains, that is a powerful window into the motor control strategies adopted by the CNS,

d) images of signal intensities averaged over suitable time epochs showing the time course of activities of muscle compartments or synergic muscles. Specific challenges will concern the interpretation of maps derived from pinnate muscles and the tracking of muscle activity during dynamic contractions when the muscle moves under the array.

CONCLUSION: The development of HDsEMG has been limited by technological bottlenecks that are being overcome. HDsEMG holds remarkable promise for the future non invasive investigation of the neuromuscular system. Training of users, clinical testing, dissemination and technology transfer are the challenges of the future.

ACKNOWLEDGMENT. The author is grateful to the staff of the Laboratory for Engineering of the Neuromuscular System (LISiN). Work supported by Bank Foundations “Compagnia di San Paolo” and “Fondazione CRT”, Torino, Italy.

WRIST TREMOR REDUCTION THROUGH A NOVEL NEURAL MODEL

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AIM: For the last few years the research has been focusing on the integration of data coming from inertial sensors, and biosignals, such as EEG and sEMG, for tremor detection and monitoring. Furthermore, since Functional Electrical Stimulation (FES) has been proposed as an approach to tremor suppression and motion support, the variables extracted from biosignals could help to define the stimulation parameters, even if the issue connected to the real-time implementation has not been overcome yet. In order to solve these problems, the present study proposes an approach based on Artificial Neural Networks (ANN), which aims at estimating the neural activations able to counteract tremor on the basis of predicted kinematic and dynamic data.

METHODS: The study has been designed on a simulation basis, where the tremorous movements have been generated by using a musculo-skeletal model of the human arm. The model can be fed with either simulated or real muscular activation patterns, and provides, as output, kinematic and dynamic data at different joints. In this study, angular position, angular velocity and torque at the wrist joint have been obtained from the model, using both simulated activations and real tremor activation patterns extracted from sEMG tremor signals. Wrist torque data (sequences lasting 200 ms) have been fed to a feed-forward ANN to predict the forthcoming 200 ms of torque pattern. At the same time two further feed-forward ANNs, one for the Extensor Carpi Radialis and one for the Flexor Carpi Radialis muscle, have been used to reconstruct the future 200 ms of neural activations driving the predicted torque pattern. The simulation of the FES effect has then been performed by applying the estimated neural activations of the agonist muscle to the antagonist one, thus simulating an out-of-phase muscle activation. The power of the residual tremor, as calculated from the torque waveforms thus obtained, is used as an indicator of the correctness of the estimated torque, and consequently as a measure of the efficacy in tremor reduction: if this power is lower than a given threshold Th, then the estimated torque is used to predict the forthcoming sequence of stimulation parameters; otherwise, the actual torque at the wrist joint is used to estimate the future neural activations.

All the ANNs used in this study have been trained offline in a supervised way, feeding them with known input-output pairs belonging to 60 different tremor simulated movements (3 s duration) with burst width and repetition frequency values spanning the ranges (60 ms - 100 ms) and (4 Hz - 7.5 Hz), respectively.

RESULTS: The system is able to reduce 50% of tremor torque at the wrist joint in the frequency range (4 Hz - 7.5 Hz) for simulated data, and 42% for real tremor activation patterns.

CONCLUSION: The proposed neural approach seems to work well when dealing with pattern prediction, for the estimation of the desired neural activation for tremor reduction. The issue of real-time implementation has been solved by accepting an initial delay of about 200 ms, in line with the hypothesis of reducing tremor in an out-of-phase fashion. Further studies should include an enhanced neural model for controlling tremor movements at more joints of the upper limb.

ACKNOWLEDGEMENTS: the present contribution has been funded within FP7 action ICT-2007.7.2 “Accessible and Inclusive ICT”, under grant N. 224051: TREMOR.

ACCELEROMETRY CHARACTERISTICS DURING A FATIGUING RUN

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AIM: The aim of this study was to evaluate the relevance of measuring accelerations of body movements in order to characterize motor control during running. Trunk accelerations are related to movement strategies by reflecting aspects of the dynamic forces, according to Newton's 2. law ($F=m*a$). The movement strategies can be expected to change when muscles are fatigued. The accelerometry method was therefore evaluated by assessing the results of a fatiguing running protocol using trunk accelerations as the outcome measure.
METHODS: Eleven healthy participants (aged 23-38 years) performed a 20-25 minutes run on a treadmill at an individual fatiguing speed between 10 and 13 km/h. The participant's experience of fatigue was monitored by Borg´s RPE scale (6-20).
Trunk accelerations were measured by a tri-axial accelerometer fixed to the lumbar back of the participant at the level of L3. Recordings were done at baseline (after a customization period) and at the termination of the run. In both recording sessions a set running speed of 10 km/h was used. The accelerometer data were collected at 200Hz and converted to a vertical/ horizontal coordinate system. The vertical, anterior-posterior and medio-lateral RMS-values were reported in the unit "g" (acceleration of gravity).
RESULTS: All participants reached a RPE score between 12 and 19. The RMS accelerations increased in all coordinate directions. The mean differences were: vertical: 0.058g (0.45), $p<0.01$; anterior-posterior: 0.028g (0.026), $p<0.01$; medio-lateral: 0.079g (0.044), $p<0.001$. The individual RMS values and changes are illustrated in figure 1.
CONCLUSION: Accelerometry is a method which is easily applied and which is sensitive to changes in motor patterns, but the results are difficult to interpret. The results from this study indicate that the accelerometer measures reflect aspects of the motor control during running, but the findings are difficult to relate to specific physiological changes without additional information. Future studies should elaborate on these findings and exploit the method by comparing groups in different experimental conditions and with different pathologies.

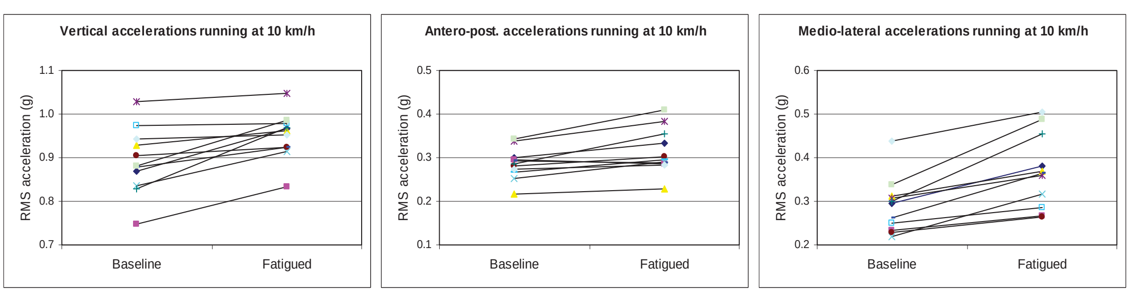

Figure 1: Changes in trunk accelerations as response to a fatiguing run shown for eleven individuals.

EFFECTS OF MUSCLE FATIGUE ON EFFORT AND MOVEMENT-RELATED CORTICAL POTENTIALS

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AIM: The primary aim of this study is to experimentally investigate the effects of muscle fatigue on movement-related cortical potentials (MRCPs), which are currently not well understood. We expect changes in MRCP amplitudes and effort as a result of the increase in central motor command necessary to perform the same submaximal task with fatigued muscles. The secondary aim is to identify which MRCP components are affected by muscle fatigue and their relationship to perception of effort.
METHODS: Twelve right-handed participants had one arm (randomly counterbalanced) pre-fatigued with eccentric exercise. Participants performed four blocks of 50 elbow flexions (± 2 s each) in a randomized order. They lifted a light weight (20% of one-repetition maximum (1RM)) and a heavy weight (35% 1RM) with the fatigued (FAT) and the non-fatigued (NF) arm with 6 s rest between lifts. Ratings of perceived effort, biceps brachii electromyogram (EMG) and 62-channel electroencephalogram (EEG) were recorded. EEG was segmented and time-locked to EMG onset (0 ms), and artefact free trials were averaged within each block. Comparisons between blocks were made using two-way ANOVA with repeated measures. P-levels of paired differences are reported.
RESULTS: The fatigued arm was on average 32% weaker than the non-fatigued arm ($p < 0.001$). Effort ratings were significantly higher for the fatigued arm compared to the non-fatigued arm for both weights (Light $p = 0.003$; Heavy $p = 0.004$). Similar effects were found for biceps EMG amplitude (see figure 1). Effects of weight and fatigue on MRCPs were found before the movement at frontal electrodes and during the first half of the movement at central electrodes. At parietal electrodes, effects of weight and fatigue were found before, during, and after the movement (see figure 1).
CONCLUSION: As expected, muscle fatigue induces noticeable changes in various MRCP components reflecting planning, execution and awareness of movement. Importantly, these changes in brain activity induced by muscle fatigue are related to perception of effort rather than actual weight, which supports the corollary discharge hypothesis of perception of effort.

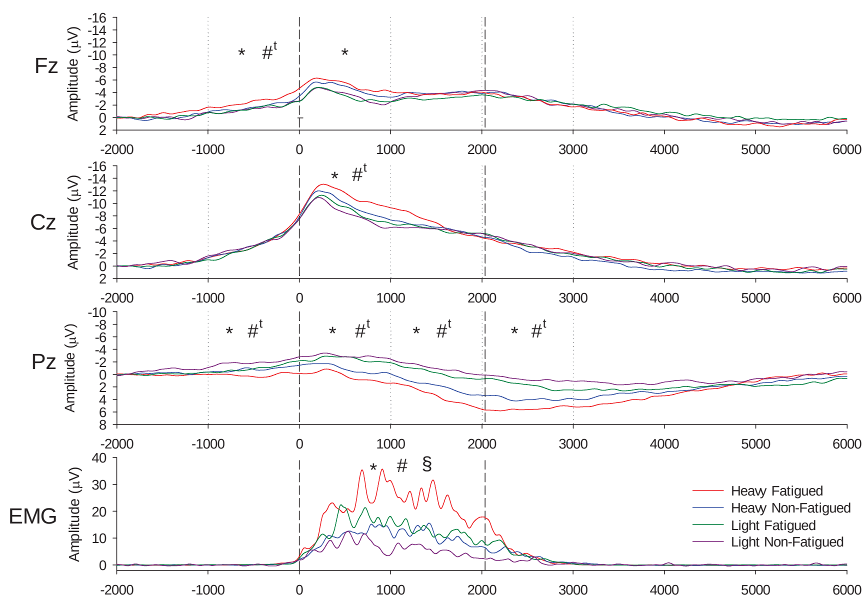

Figure 1: Traces of biceps EMG and three midline electrodes: frontal, central, and parietal. * Significant main effect of weight, # significant main effect of fatigue, § significant weight x fatigue interaction, ^{t} trend ($p < 0.1$).

PHYSIOPATHOLOGY OF HETEROGENEOUS SKELETAL MUSCLE ACTIVATION THROUGH HDEMG.

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AIM: Although it has been technically possible for many years to place many electrodes on the skin above the muscle of investigation, still the majority of electrophysiological investigations are done with one electrode pair in or on the muscle. Such single leading investigations of muscle activation can only be used to investigate a specific part of the muscle. Although most muscles seem to be mechanically homogeneous (activation of different parts of the muscle can result in the same torque production around the joint), specific parts can be activated at different force levels, in different tasks and in different situations. By applying high density surface electromyography (HDEMG), one can investigate this spatial heterogeneous single muscle activation by analyzing the spatio-temporal variation in amplitude. The aim of this contribution is to give several examples from my own research and that from others of how the spatio-temporal variation in amplitude can be used to get insight in motor unit recruitment, muscle endurance and fatigue and neuromuscular pathology.
METHODS: In the literature, quite a few different methods can be found that have been used to analyze HDEMG to investigate variations in the amplitude distribution in several muscles. In general, many electrodes are placed in a grid over the muscle to cover a large part of the muscle. Often, the first step of analyses contains the calculation of the root mean square (RMS) values for the signal of each channel in specific time epochs, giving 2-dimentional RMS maps. Then, for example, the change of the center of gravity or the correlation between successive 2D RMS maps can be obtained. By de-trending and normalizing the signals obtained from electrodes above two different regions of a muscle, so-called differential activations can be investigated.
RESULTS: Surface EMG amplitude distributions over all muscles investigated were non-uniform, indicating some level of heterogeneous activation, justifying further investigation of amplitude distributions. The amplitude distribution can vary between individuals and changes with contraction level and during sustained contractions. It has been shown that the distribution and its dependency on contraction level are highly reproducible between trials in the same individual. Throughout sustained contractions, the distribution is shown to become increasingly similar to distributions measured at higher force levels. Moreover, investigation of change in amplitude distribution has shown that pain alters the adaptation of muscle activation during sustained contractions, and that this is gender specific. The frequency of fluctuations in differential activation is related to endurance in healthy males during low force contractions, but not during high force contractions. In addition, frequency of differential activation signals at very low load levels was significantly different in patients with fibromyalgia compared with controls.
CONCLUSIONS: Several studies have shown that HDEMG can be used to investigate heterogeneous muscle activation. However, there is no consensus on how this should be quantified and a critical review on different methods is lacking. Despite methodological differences, the studies showed that this variation in amplitude distribution sheds new light on muscle endurance and fatigue and some pathological phenomena. In addition, there are indications that spatiotemporal variation is trainable which might be useful in rehabilitation.

RELIABILITY OF CENTER OF PRESSURE MEASURES OF POSTURAL STABILITY IN HEALTHY OLDER ADULTS: EFFECT OF DUAL-TASKING AND SENSORY CONTEXT

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AIM: Postural instability is a major risk factor of falling in the elderly. It is well documented that postural control may decline while performing a concurrent cognitive task and this effect increases with age. Despite the extensive use of dual tasking in balance assessment protocols, a lack of sufficient reliability information is evident. This study aimed to determine the reliability of the postural stability measures in older adults, assessed under single and dual-task conditions and different levels of postural difficulty.
METHODS: Sixteen older adults randomly completed quiet stance postural measurements at three levels of difficulty (rigid surface-eyes open, rigid surface-eyes closed, and foam surface-eyes closed), with or without performing a concurrent backward counting task, in two sessions 1 week apart. Force plate data was used to calculate center of pressure (COP) parameters including mean total velocity, phase plane portrait, area (95% confidence ellipse), standard deviation (SD) of amplitude, and SD of velocity. Intraclass correlation coefficient (ICC), standard error of measurement (SEM), and coefficient of variation (CV) were calculated for each COP measure in all test conditions.
RESULTS: Paired t-tests on the mean difference between the scores on the two measurements revealed no statistically significant systematic bias ($p > 0.05$). For both single and dual-task conditions, mean total velocity, phase plane (AP/ML), phase plane (ML), and SD of velocity (ML) were the most reliable COP measures having high to very high reliability across all levels of postural difficulty (ICC range, 0.70 to 0.98). Patterns of the CV values were greatly consistent with the ICCs so that for most conditions mean total velocity, phase plane (AP/ML), phase plane (ML), and SD of velocity (ML) had lower values relative to other measures (CV range, 1.85 to 15.54%).In addition, for phase plane and SD of velocity the ICC values were consistently higher in the ML than the AP direction. A similar pattern was evident for CV and SEM values, which were lower in the ML than the AP direction except for the foam-closed dual-task condition.
CONCLUSION: Mean total velocity, phase plane (AP/ML), phase plane (ML), and SD of velocity (ML) showed high to very high reliability, consistently in all levels of postural difficulty for both single and dual-task conditions. In general, the velocity-related COP measures in ML direction showed better relative and absolute reliability compared with other COP measures. Further research may use these results to determine the evaluative and predictive value of the COP parameters.

NEUROMUSCULAR CONTROL: MODELING ISOMETRIC FORCE EXERTION AND TREMOR

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AIM: In motor output the fluctuations in movement and force during the performance of contractions differ depending on different types of loads and fatigue. Mainly three types of regular oscillations are distinguished: (1) Resonance of the mechanical mass-spring-damping system (round about: arm 5 Hz, hand 10 Hz, finger 20 Hz), (2) Oscillations of the peripheral reflex loop, and (3) Central oscillator with fixed 4.5 Hz. This study was to focus on the fluctuations in the force output during slow rate isometric contractions. In healthy subjects situation (3) can be excluded while situation (2) is also excluded or at least highly suppressed.
METHODS: To demonstrate the minimum requirements and the conditions for generating reflex loop oscillations a model has been established consisting of a constant or a spring/damping in the forward loop, and a transport delay combined with an adjustable gain in the feed back loop. It is assumed that the muscle length is constant, and consequently the muscle spindles are not to be considered. The model has been calculated by (a) in the frequency domain numerically, and (b) in the time domain by using SIMULINK. Measurements of isometric force exertions during hand torque and of the EMG fluctuations observed at the Extensor Carpi Radialis Longus muscle has been used to verify the model.
RESULTS: The delay time in the reflex loop for the hand extensor muscle can be assumed with a transport component consisting of nerve conduction and a synaptic delay, but in addition a delay time of the force sensor (most probably the Golgi tendon sensor) and a delay due to the muscle EMG command causing the force development. Together, it results in about total of 50 ms. The loop resonances are for positive feedback 10,30,… Hz, for negative feedback 20, 40,… Hz. A crucial test is an isometric force change with constant rate. During the ramp increase the force showed discontinuous steps. Those steps could also be observed during decrease. The step width and size changed dependent on the steepness of the ramp. As published earlier, the physiological measurements, fluctuations in force were observed at the frequency of 10-12 Hz. They corresponded to the EMG fluctuations. The amplitude fluctuations increased with increase as well as with decrease of the force ramp. If the level of force was kept constant the fluctuation were very small in value.
CONCLUSION: A minimum linear reflex loop model yielded a force output behavior which essentially seems in agreement with the observed physiological characteristics. The results are obtained when only one muscle is assumed to be activated. Since in the activation of a muscle many motor units are involved, and the motor-neuron pool has been reported never to show a complete synchronization, the crisp model has to be modified. Also, the change in loop gain depends on the sensor characteristics which have been assumed also to be linear. If a non-linearity is introduced, the tendency to oscillations may be increased while the system does not become instable. In literature, it has been reported that during a fatiguing contraction the loop gain increases. It will be necessary to define different types of movement and contraction modes. The results specifically open the extension to investigate the agonist-antagonist system respectively, and then the stepwise movement phenomena in different movement types may be addressed which have been described already in 1928 by Wacholder.

NEUROMUSCULAR RESPONSE OF LOW BACK MUSCLES TO DIFFERENT WORKLOADS IN ADOLESCENT ROWERS

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AIM: The aim of this study was to test the effect of different workloads on the EMG activity of Erector Spinae - ES (L4-L5 level) and Rectus Abdomen – RA in a group of adolescent rowers after a two-months training program.
METHODS: Six subjects (Age: 14±0 years; Body mass: 61.4±11.8 kg; Stature: 1.69±0.07m) attended the lab on two occasions. During the first session all subjects performed a maximal test with a row ergometer consisting of a 1500m bout (pace: 22 strikes per minute). A week later, subjects were subdivided in two groups each performing a sub-maximal test at 55% and 75% of the maximal power obtained during the maximal test, respectively. During both maximal and sub-maximal tests the EMG activity was recorded from the Rectus Abdomen – RA- and Erector Spinae –ES (L4-L5 level) bilaterally through a wi-fi portable EMG device (BTS-Pocket EMG, Italy). All these measurements were performed before and after a two-months training program. The EMG was full wave rectified; to provide a description of the EMG amplitude variation overtime, the EMG bursts obtained during the first and last 250m of each 1500m bout were averaged (maximal and sub-maximal trials).
RESULTS: During the maximal test, the ES and RA EMG amplitude did not vary overtime. During the sub-maximal test performed at 55%max power the ES EMG decreased between the beginning and the end of each 1500m bout, showing an EMG recovery during the 5-min interval. A similar behaviour was observed in the trials performed either before or after training. Conversely (Figure 1) in the sub-maximal test performed at 75%max power, no variation of the ES EMG amplitude was observed between the beginning and the end of each 1500m bout; moreover, the 5-min interval didn't allow a convenient EMG recovery between subsequent bouts.
CONCLUSION: The absence of an EMG recovery in the maximal test and in the sub-maximal test performed at 75%max power, along with the absence of an EMG recovery between subsequent bouts suggests that: 1) A 5-min rest between series is not enough to allow a convenient EMG recovery if the workload exceeds a target load; 2) the power corresponding to 75%max represents, in this experimental condition, the target load over which an increased risk of developing an acute low back pain could be invoked.

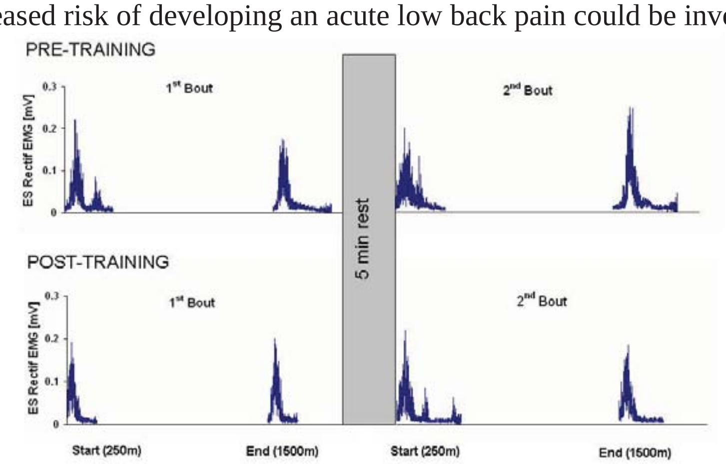

Figure 1: ES EMG response Before and After Training during a sub-maximal test (75%max power) in one subject.

DISCHARGE VARIABILITY OF MOTOR UNITS IN SOLEUS MUSCLE DURING QUIET STANDING AND ITS RELATION TO POSTURAL SWAY

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AIM: Activities of plantar flexor muscles have been found to be coherent with spontaneous body sway during quiet standing (Kouzaki & Fukunaga 2008). However, spatio-temporal relation between motor unit (MU) discharge pattern and postural sway remains unclear. Present study examined whether MU discharges of soleus muscle are correlated with postural sway during quiet standing.
METHODS: Seven male subjects (age: 25.6 ± 6.0 year) maintained a quiet standing with eyes open and closed for 60 seconds. Center of pressure (CoP) was obtained from the vertical components of the force platform. MU action potentials were recorded with two bipolar fine-wire electrodes inserted into the soleus muscles. Action potentials discharged by single MU were discriminated based on waveform amplitude, duration, and shape. To evaluate the extend of correlation and the time relation between the discriminated MUs and CoP, cross-correlation function (CCF) between the variables was calculated. From ramp contraction task, the recruitment threshold of the MUs was determined.
RESULTS and Discussion: Lower recruitment threshold MUs continuously discharged for entire task. In contrast, relatively higher recruitment threshold MUs exhibited phasic activity. This result may indicate that individual MUs of soleus muscle were not similar discharge pattern, rather their discharge pattern was different. With respect to CCF results, most of MUs positively correlated with CoP sway. However, a small number of MUs negatively correlated with CoP sway. With respect to recruitment threshold of MUs, relatively higher recruitment threshold MUs were higher CCF values than lower recruitment threshold MUs. This may suggest that CoP fluctuations resulted from relatively higher MUs discharge.
CONCLUSION: It was concluded that discharge variability of MUs in soleus muscle during quiet standing are correlated with postural sway. We speculated that relatively higher recruitment threshold MUs generate the postural fluctuations during quiet standing.
ACKNOWLEDGEMENT: This study was supported by the Descente and Ishimoto Memorial Foundation.

REFERENCSES:
Kouzaki & Fukunaga. *J Neurosci Methods* 173: 241-248, 2008.

MACHINE LEARNING AND DATA MINING FOR EEG SINGLE-TRIAL PRIOR DETECTION OF VOLUNTARY MOVEMENT

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AIM: The main objective of the work is the proposal and assessment of a methodology for constructing and optimizing online predictors of voluntary movements before the onset, from the power spectrum of EEG single-trial signals. This prior detection of movement will be used later on by a robotic exoskeleton for the control of tremor suppression.
METHODS: EEG signal was recorded from three control subjects (with no tremor pathology) while doing a task during different sessions. The task lied in performing sequential voluntary wrist extensions, from a rest position, whenever they wanted after hearing an auditory stimulus (one per movement), and then going back to the rest position. The recording was carried out using a g-tec 65 electrode g.EEGcap and a g.USBamp amplifier at 256Hz. Signal was recorded from channels FC3, FCz, FC4, C5, C3, C1, Cz, C2, C4, C6, CP3, CPz, CP4 with a Notch filter (50Hz) and B-P filter (0.5Hz-100Hz). For each channel, the signal was processed and filtered in overlapping bands of 2Hz within the alpha band (8Hz - 13Hz). For each frequency band, the entire signals of the sessions were fragmented into both premovement windows (the time windows 0.25s before the movement onsets) and baseline windows (the time windows 5s before movement onsets). Three different window sizes were tested: 1s, 2s and 3s. For each window size, an Evolutionary Strategy (ES) together with a Naïve Bayes classifier was applied using the spectral power of the corresponding extracted windows from all the channels and frequency bands mentioned above, in order to obtain the combination of channels, bands and window size that distinguishes the best between voluntary premovement activity and any kind of activity else.
RESULTS: The most discriminatory channels for the three subjects were among C1, C3, Cz, C2, C4 (both lateral and contralateral to movement), where ERD/ERS is most likely to appear, but more posterior channels (CP3, CP4) showed an even higher discrimination capacity. No kind of combination of channels meant an improvement. Best frequency bands varied among subjects. For all the subjects, the best classification performance was reached in windows of 3s, presenting accuracies between 67% and 82%. Figure 1 shows the results of the optimized premovement prediction for one the sessions of the best subject.
CONCLUSION: Machine learning plus data mining evolutionary techniques allow the automatic construction and optimization of online predictors of single-trial EEG voluntary movement, regardless of the subject. This same methodology will be applied to the prior detection of voluntary movements in patients with tremor.

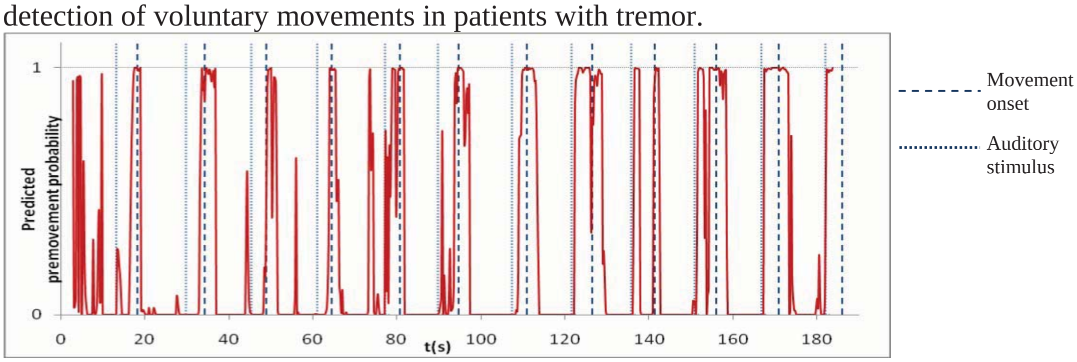

Figure 1: Voluntary movement prediction results for the best subject during one session.

AN ORIGINAL STUDY OF MASTICATION IN PATIENTS WITH ADVANCED PARKINSON DISEASE WITH AND WITHOUT THERAPY AND DEEP BRAIN STIMULATION

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AIM: Mastication is a rhythmic movement, expression of a co-ordinate neuromuscular function. The chewing cycles evaluation in patients with Parkinson disease is original. The aim of this research is to evaluate the characteristics of kinetic and electromyographic pattern in different therapeutical conditions.
METHODS**:** Three patients with advanced Parkinson disease treated with medical therapy and Deep Brain Stimulation (DBS) of the Subthalamic Nucleus (STN) were evaluated. Chewing pattern and electromyographic activity of masseters and anterior temporalis muscles were contemporary recorded with a Kinesiograph K7, Myotronics Inc. Tukwila, WA, USA, interfaced with a computer. The protocol includes deliberate chewings on the right side, on the left side and non-deliberate. Each set was repeated three times with soft and hard bolus. The chewing cycles were recorded, before neurosurgery, in conditions with medical therapy (med on), without medical therapy (med off), after neurosurgery, in conditions with DBS (stim on), without DBS (stim off), with DBS on the right side (stim on dx) and with DBS on the left side (stim on sx).
RESULTS: An increase of dyskinetic chewing patterns and of neuromuscular in coordination in condition of med on with respect to med off and a decrease of dyskinetic cycles during stim on with respect to stim off was observed.
CONCLUSIONS: This preliminary original study let to establish a non-invasive protocol to evaluate the influence of the medical therapy and of STN DBN on chewing patterns which will be applied on a greater number of patients. Further investigations are required to establish a deeper understanding of the STN's role on chewing and neuromuscular control.

M-WAVE PROPERTIES AFTER ECCENTRIC AND CONCENTRIC EXERCISES

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AIM: It has been shown that sarcolemmal excitability and action potential conduction may be impaired acutely after eccentric exercise, which could partly explain the accompanied loss of muscle force production. However, it is not clear if this applies to exercise models with different mechanical nature.
METHODS: Multichannel surface electromyography (sEMG) characteristics were examined from short head of biceps brachii muscle during supramaximal monopolar transcutaneous motorpoint stimulation (30 s train of M-waves with 30 Hz) before (BEF) and immediately (IA), 30 min (30MIN) and two hours (2H) after maximal eccentric (ECC group, N=12) and concentric (CON group, N=12) elbow flexor exercises. In addition, voluntary activation level (VAL) was tested with bipolar double pulse (inter-pulse interval 10 ms) stimulation superimposed over isometric maximal voluntary contraction (MVC) and relaxed muscle at BEF and at 2H measurement points.
RESULTS: Isometric MVC force decreased in CON group by 21.7 ± 12.0 % ($p<0.01$) and ECC group by 30.0 ± 17.7 % ($p<0.001$) at IA. Moreover, only ECC group showed reduction at 2H (by 24.7 ± 13.7 %, $p<0.01$) and this was greater ($p<0.01$) than in CON group (by 8.0 ± 17.0 %). Greater reductions were also observed in mean muscle fiber conduction velocity (CV) and mean power frequency (MNF) of M-waves in ECC group than in CON group at 2H post exercise (Fig. 1). VAL showed reduction in ECC group after the exercise (from BEF: 84.7 ± 11.8 % to 2H: 73.4 ± 16.1 %, $p<0.05$). However, this reduction in VAL was not significantly different from the CON group (from BEF: 86.4 ± 10.1 %, to 2H: 82.9 ± 10.3 %).
CONCLUSION: Both eccentric and concentric exercises can induce reduction in both maximal voluntary force production of the elbow flexors and action potential conduction over the sarcolemma of the affected muscle fibers. However, these reductions are significantly greater after eccentric than after concentric exercise. Furthermore, since the change in VAL did not differ between the groups after the exercises, reduced central drive to muscle can not by itself explain the greater effect of eccentric exercise on muscle force production. Instead, the impairment seems to lie at the sarcolemmal level and beyond it (e.g. transverse tubular system) after strenuous exercise.

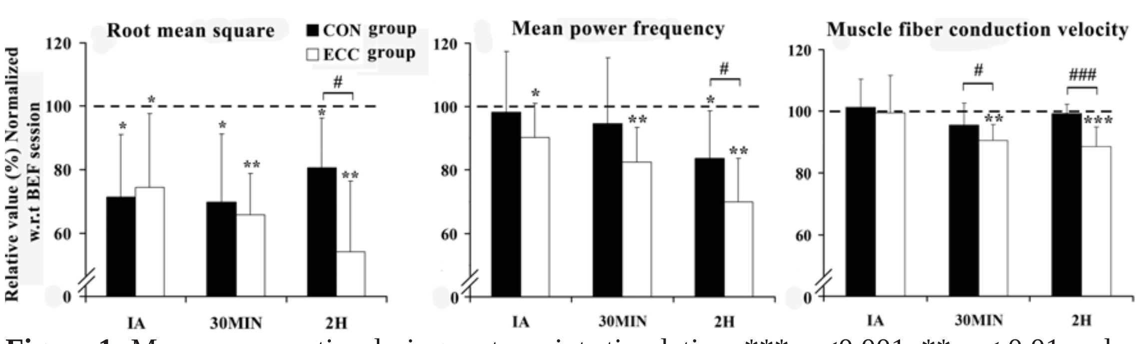

Figure 1: M-wave properties during motorpoint stimulation. ***=p<0.001, **=p< 0.01 and *=p<0.05 with respect to BEF. ###=p<0.001 and #=p<0.05 difference between the groups.

SPATIAL DIFFERENCES IN PRESSURE PAIN THRESHOLD FROM THE TRAPEZIUS MUSCLE IN CLEANERS AND CONTROLS

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AIM: The aim of the present study was to map and examine the spatial distribution of pressure pain threshold (PPT) from the shoulder by covering the trapezius muscle with a high number of measurement sites. Further, we wanted to obtain this spatial distribution in both a group of university cleaners, with reported pain and soreness in the shoulder region, and a healthy control group.
METHODS: 29 cleaners (3 males and 26 females) and 22 controls (11 males and 11 females) participated in the study. PPTs were measured using a hand hold algometer (Somedic® Algometer type 2, Sweden) with a 1 cm^2 wide rubber tip, which was pressed perpendicular to the skin surface at a constant velocity of 30 kPa/s. A recording grid consisting of 36 points was used to cover the trapezius muscle on the dominant side and 12 points were used to cover the spine from the 1st cervical to the 10th thoracic vertebrae. The distance between neighboring points was computed as a fraction (1/6) of the distance between the 7th cervical vertebrae and the acromion. For statistical analysis the points were divided into four regions (see fig. 1). A two-way ANOVA was used. $P<0.05$ was considered significant.
RESULTS: The ANOVA showed significant difference between regions ($P<0.001$) and subject groups ($P<0.001$) but no interaction ($P=0.45$). The cleaners' group had overall lower PPTs than the control group (306±5 kPa vs. 338±4 kPa, see fig. 1), and the upper region of the muscle was the most sensitive in both groups.
CONCLUSION: The spatial distribution of pressure pain sensitivity was highly dependent on location and muscle tissue type. The presence of soreness and pain resulted in a reduction of PPT for the cleaners compared with the control group highlighting deep structure hyperalgesia.

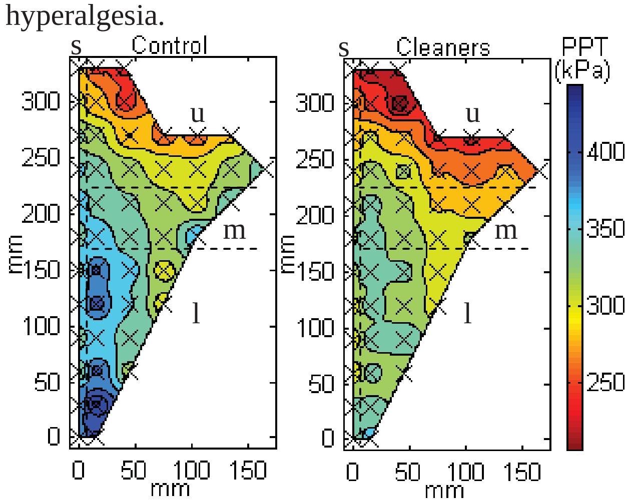

Figure 1: PPT (kPa) for control subjects (N = 22) and cleaners (N = 29). u: upper, m: middle, l: lower trapezius, s:spine.

THE EFFECT OF UNILATERAL LEG MUSCLE FATIGUE ON STABILITY OF WALKING

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AIM: The effects of unilateral leg muscle fatigue on several measures of walking stability were studied in healthy elderly subjects.
METHODS: Stability of walking was assessed, on a treadmill at 3 km/h, in 11 healthy elderly subjects (63.4 SD 5.5 years) before and after a fatiguing protocol. The fatiguing protocol consisted of single-leg knee bending (0.25 Hz) until exhaustion. Fatigue was quantified by determining the decrease in maximum voluntary torque generating capacity (MVT) of the knee extensors immediately after the fatiguing protocol. Stability of walking was quantified by the short term Lyapunov exponents of 3D trunk movement (λx_s, λy_s and λz_s), the short term Lyapunov exponents of the knee angle time series of the unfatigued and fatigued leg (resp. λkuf_s and λkf_s), step width (SW), step length (SL), double support time (DST) and stride time variability (STV). Indicators of less stable walking are larger short term Lyapunov exponents, SW, DST or STV and a shorter SL.
RESULTS: The fatiguing exercise resulted in a significant decrease of MVT (-17.2%, 95%CI: -10.6% – -23.7%), indicating that a substantial degree of fatigue was present. After the fatigue protocol λx_s, λy_s, λz_s, λkuf_s and λkf_s were significantly lower than before (see table 1). There was a nearly significant decrease in SW as a result of the fatiguing protocol. There was no significant change in SL, DST, and STV.
CONCLUSION: SL, DST and STV did not change as a result of unilateral leg muscle fatigue. However, the significant decreases with fatigue in the short term Lyapunov exponents of trunk and knee angle time series after unilateral leg muscle fatigue, indicate that subjects show a more stable walking pattern. A similar trend was found for SW. The increased walking stability is probably indicative of a compensatory strategy, possibly to compensate for the decreased proprioception and potential for active corrections after fatigue.

Table 1: Changes in measures of stability of walking. For abbreviations see methods.

Variable	Pre fatigue	Post fatigue	Mean change (95% CI)	p
λx_s	3.238	2.936	-0.301 (-0.541 – -0.301)	0.019
λy_s	2.634	2.448	-0.186 (-0.326 – -0.046)	0.015
λz_s	2.571	2.364	-0.207 (-0.302 – -0.112)	0.001
λkuf_s	3.615	3.359	-0.256 (-0.411 – -0.102)	0.004
λkf_s	3.369	3.125	-0.244 (-0.338 – -0.149)	0.000
Step width	0.081	0.068	-0.013 (-0.026 – 0.000)	0.054
Step length	0.579	0.577	-0.002 (-0.023 – 0.018)	0.807
Double support time	24.798	24.890	0.092 (-0.689 – 0.872)	0.799
Stride time variability	0.033	0.035	0.003 (-0.002 – 0.008)	0.228

[1]Step width, step length in metres. [2] Double support time in % gait cycle.

WALKING ON HIGH HEELS CHANGES MUSCLE ACTIVITY AND THE DYNAMICS OF HUMAN WALKING SIGNIFICANTLY

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AIM: To investigate the distribution of net joint moments and thereby forces at the joints of the lower extremities during walking on high-heeled shoes compared to bare-footed walking at identical speed.
METHODS: Fourteen subjects walked at 4 km/h across three force platforms while they were filmed by five digital video-cameras operating at 50 frames/second. Both bare-footed walking and walking on high-heeled shoes (heel height: 9 cm) were recorded. Reflective markers were placed at specific anatomical landmarks. Three dimensional coordinates of the markers were reconstructed by The Ariel Performance Analysis System (Ariel Dynamics, CA, USA). Net joint moments were calculated by 3D inverse dynamics. Characteristic peak values from three trials were identified in joint moment and joint angle data. These values were input to a *Mixed Model* using SAS software. Level of significance was set to 5%.
On a separate day the same subjects walked on a treadmill (TechnoGym HC1200) at 4 km/h while EMG was recorded from eight leg muscles by use of a wireless EMG system (MQ16, Marq-Medical, Farum, Denmark). Linear envelopes from 15 gait cycles were averaged and expressed relative to maximal EMG amplitude measured during isometric contractions. Differences in EMG amplitude and integrated EMG (IEMG) were tested by a paired t-test with the level of significance set to 5%.
RESULTS: The peak ankle joint moment in the sagittal plane was significantly lower during high-heeled walking and as expected the ankle joint angle was significantly more plantar flexed all through the stance phase. The peak knee extensor moment peak in the first half of the stance phase was almost doubled when walking on high heels. The knee joint angle showed that high-heeled walking caused the subjects to flex the knee joint significantly more in the first half of the stance phase. The hip joint moment in the sagittal plane was unchanged as was the hip joint angle. In the frontal plane significant but rather small increases were observed in the knee joint abductor moment and the hip joint abductor moment. The hip joint angle in the frontal plane was unchanged. IEMG increased significantly from bare-footed to high-heeled walking in all muscles recorded except the anterior tibial muscle (TA). Peak EMG amplitude was significantly higher during high-heeled walking except in the medial gastrocnemius muscle (GAM) and also mean amplitude was higher except for the GAM and the TA. At the instant of peak EMG amplitude in the soleus muscle (SOL) when push off takes place at the ankle joint, co-contraction between SOL and TA was significantly higher during high-heeled walking.
CONCLUSION: Reduction of the net ankle joint moment during push off (high-heeled walking) was clearly caused by increased co-contraction about the ankle joint and the increased knee joint extensor moment was followed by increased EMG in the quadriceps muscle. The latter indicates a large increase in bone-on-bone forces in the knee joint caused by high-heeled walking, which may explain the observed higher incidence of osteo-arthritis in the knee joint in women as compared to men.

CHANGES IN EMG VARIABILITY IN THREE STANDING BALANCE CONDITIONS

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AIM: This work examines changes in the variability of electromyographic (EMG) activity of tibialis anterior and gastrocnemius medialis as a result of three upright standing balance conditions.

METHODS: Thirty two participants (16 men and 16 women; age: 23.72 ± 2.80 years; height: 1.68 ± 0.09 m; mass: 64.66 ± 8.70 kg) were asked to stand still in a bipedal standing position on the Biodex Balance System (BBS; Biodex, Inc., Shirley, NY) under three balance conditions: standing on a static surface (stable), and standing on an unstable surface at level 6 and level 1 of BBS (medium and high instability, respectively). Surface EMG activity was collected from tibialis anterior and gastrocnemius medialis using MP100 (Biopac, CA). Anterior–posterior (AP) and medial-lateral (ML) sway variables were also collected. EMG variability was measured using the coefficient of variation (CV) of the root mean square of the normalized EMG amplitude (30 ms time frame). Regularity of the raw EMG signal was measured using Fuzzy Entropy.

RESULTS: Repeated-measures ANOVA showed that the AP and ML sway and the CV of the EMG amplitude increased when the difficulty of the balance task also increased from stable to high instability, except for left gastrocnemius medialis between levels 6 and 1 of BBS (table 1). However, Fuzzy Entropy decreased as difficulty increased, showing more regular signals in the unstable surface conditions.

CONCLUSION: Results suggest an adaptation to unstable bipedal standing by increasing the lineal variability (CV) and the regularity of the EMG of the lower limb muscles.

Table 1: Mean and standard deviation of sway variables (ML, AP), coefficient of variation (CV) and Fuzzy Entropy (FuzzyEn) of tibialis anterior (TA) and gastrocnemius medialis (GM) for static surface and labile surface conditions of the Biodex Balance System (BBS).

	N	Static (stable)	Level 6 of BBS (medium instability)	Level 1 of BBS (high instability)
ML (º)	32	0.19 ± 0.16	0.61 ± 0.31^{A}	1.86 ± 1.58^{AB}
AP (º)	32	0.26 ± 0.10	0.91 ± 0.41^{A}	2.43 ± 1.94^{AB}
Right TA FuzzyEn	32	1.76 ± 0.31	1.18 ± 0.44^{A}	0.93 ± 0.22^{AB}
Right TA CV (%)	32	13.15 ± 11.01	39.62 ± 22.18^{A}	56.61 ± 17.08^{AB}
Left TA FuzzyEn	32	1.82 ± 0.26	1.26 ± 0.41^{A}	1.06 ± 0.26^{AB}
Left TA CV (%)	32	5.58 ± 7.38	28.33 ± 20.21^{A}	48.53 ± 25.96^{AB}
Right GM FuzzyEn	32	1.26 ± 0.28	1.05 ± 0.28^{A}	0.89 ± 0.26^{AB}
Right GM CV (%)	32	28.46 ± 12.79	41.99 ± 16.18^{A}	56.01 ± 17.97^{AB}
Left GM FuzzyEn	32	1.24 ± 0.36	0.98 ± 0.23^{A}	0.91 ± 0.24^{Ab}
Left GM CV (%)	32	41.34 ± 19.39	60.40 ± 17.71^{A}	65.96 ± 17.36^{A}

[A] Significantly different from static with $p < .01$; [B] Significantly different from level 6 of BBS with $p < .01$; [b] Significantly different from level 6 of BBS with $p < .05$

EFFECT OF TENDON VIBRATION ON MOTOR UNIT ACTIVITY AND PERCEPTION OF FORCE DURING VOLUNTARY CONSTANT-FORCE CONTRACTION

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BACKGROUND: When vibration is applied to the distal tendon of muscle during voluntary contraction, the perception of force and the cardiovascular response are reduced (Goodwin et al., 1972; Ogoh et al., 2002). These responses can be explained to occur by the reduced central command necessary to achieve a given force with the reflex facilitation elicited by vibration. In a situation with changes in perception, however, the motor unit activities remain unclear.
AIM: This study, using electromyography (EMG) and near infrared spectroscopy (NIRS), examined effects of manipulation of peripheral afferent by tendon vibration on motor unit activity during voluntary constant-force contraction.
METHODS: Subjects performed voluntarily isometric knee extension with a knee angle of 90 deg at 30% maximal voluntary contraction for 2 min with tendon vibrations (VOLVIB) and without (VOL). The sense of effort was recorded using a 1–10 category scale during the contractions (Saito et al., 1989). Surface EMG were recorded from vastus medialis (VM), vastus lateralis and rectus femoris (RF) and biceps femoris muscles. The changes in oxygenated haemoglobin (oxyHb), deoxygenated haemoglobin, and total haemoglobin in VM and RF were recorded using NIRS. Vibratory stimulation was applied perpendicularly to the patella tendon with 75 and 100 Hz frequency and 0.5–0.8 mm displacement.
RESULTS: The sense of effort gradually increased with the contraction time in both VOL and VOLVIB. At 1 min, however, the sense of effort in VOLVIB was significantly lower than that in VOL. In contrast, no significant difference was found in the integrated value of EMG of agonist and antagonist muscles between VOL and VOLVIB at 1 min. Furthermore, the decreases in oxyHb in VM and RF were not significantly different under either condition.
CONCLUSION: Results suggest that even when changes in neural input information by tendon vibration strongly affect the perception of force, motor unit activity is controlled by motor central commands during voluntary constant-force contraction.

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ASSESSING CHANGES OF MOVEMENT KINEMATICS AND DYNAMICS DURING ROBOT-AIDED NEUROREHABILITATION

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AIM: To measure the changes of movement kinematics and dynamics during robot-aided neurorehabilitation of subjects after stroke and to evaluate how much these parameters can be useful to estimate the outcome measures provided by the clinical scales.
METHODS: The study was conducted in a group of 18 subjects after chronic stroke who underwent robot therapy of the upper limb. We used some measures of movement kinematics and dynamics to assess patients' performance during each session of training. The relationship between the force control parameter (FCP), force directional error (FDE), mean velocity (MV), movement smoothness (SM) values and the clinical variables was assessed by simple and multiple regression.
RESULTS: Table 1 summarizes the r and p values of the regression analysis carried out to model the relationship between the Fugl-Meyer scale and the Motor Status Score by the robot measured variables (PRE and POST treatment values). The model fitted by the multiple regression including all the robot measured parameters was represented by the following formula: FM= 40.567 - 0.353*nFCP - 0.217*FDE - 0.003*MV + 0.179*SM. The MSS variable showed lower r values than those obtained for the Fugl-Meyer scale.
CONCLUSION: In spite of the fact that our chronic patients showed a significant improvement in the clinical scales only moderate correlation was found between the clinical scale values, the nFCP and FDE. The model obtained by the multiple regression indicates that the nFCP is the major contributor and that the mean velocity does not contribute at all to the prediction of outcome measures; also for this model the correlation was moderate.

ACKNOWLEDGEMENT: This work was partly supported by the EU grant FP/-ICT-271724 HUMOUR.

Table 1: Simple regression results between clinical scales, and robot measured variables.

	Clinical Scales			
	FM Scale		**MSS Scale**	
Performance Measures	r	p	r	p
NFCP	0.56	< 0.001	0.49	0.002
FDE	0.55	0.001	0.48	0.003
MV	0.45	0.009	0.39	0.020
SM	0.54	0.001	0.48	0.003

RELATIONSHIP BETWEEN TORQUE AND ANGLE IN ELBOW FLEXOR MUSCLES DURING ISOMETRIC AND ANISOMETRIC CONTRACTIONS IN STROKE PATIENTS AND ABLE BODIED SUBJECTS

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BACKGROUND: Studies of isometric torque-angle relationship in stroke patients have demonstrated an altered relationship throughout the range of motion (ROM), with a more pronounced weakness at short muscle length. In normal subjects, torque-angle curves are rather similar irrespective of contraction mode (isometric, concentric or eccentric), resulting in similar eccentric to concentric torque ratios (E/C ratio) throughout ROM. E/C ratios have generally been found to be about 1.2-1.7 in healthy persons. However, to our knowledge, no analysis of torque-angle curve has ever been made in individuals with stroke, using both isometric and anisometric (concentric and eccentric) testing protocols.
AIM: To examine isometric and anisometric elbow flexor joint torque-angle curves, and E/C ratios throughout ROM in individuals with stroke and in healthy control subjects.
METHODS: Eleven individuals with poststroke hemiparesis (50-75 years of age) and 11 age and gender matched controls were recruited. Stroke subjects should demonstrate strength loss in elbow flexors compared to unaffected side, but be able to perform voluntary elbow flexions against gravity throughout the full ROM (>120°). All subjects performed maximum isometric elbow flexor contractions at five angles of elbow flexion (25°, 45°, 65°, 85° and 105°). Maximum isokinetic concentric and eccentric elbow flexion contractions throughout a ROM of 120°, at movement velocities of 30° and 90°.s^{-1} were performed, where only data from 30°.s^{-1} is presented. Before analysis, a truncated range of 100° (from 15° to 115° of the full ROM) was divided in five parts of equal range, corresponding to isometric test angles. Highest obtained mean torque value from each part was selected and used for analysis. In order to compare torque-angle curves between groups, absolute torque values were normalized to torque values produced during maximum voluntary isometric contraction. E/C ratio was calculated for each of the five parts. To determine if there was any difference in torque–angle curves and E/C ratios between groups, a two factor repeated measures analysis of variance (RM-ANOVA) was performed.
RESULTS: Stroke group normalized torque-angle curves were significantly altered compared to the control group for isometric (p=0.028) and concentric contraction modes (p=0.01), but not for eccentric (p=0.49) mode. Stroke mean values at the most inner part of ROM (105 degrees) was found to be 81%, 63% and 91% of control group values for isometric, concentric and eccentric modes respectively. Mean (±SD) control group E/C ratio was rather constant throughout ROM (between 1.5 ± 0.3 and 1.6 ± 0.3). Stroke group E/C ratio was similar to control group ratio at the most outer part of ROM (25°) (1.5 ± 0.3). However, there was a linear increase of the ratio throughout ROM and the ratio was 3.2 ± 2.4 at the most inner part. According to the RM-ANOVA, the difference was nearly significant (p=0.052).
CONCLUSION: Stroke group isometric, concentric (but not eccentric) torque-angle curves were significantly altered compared to control group. Altered concentric torque-angle curve resulted in a joint-angle dependent increase of the E/C ratio.

ESTIMATION OF STARTING FREQUENCY IN TETANIC PROGRESSION FROM TWITCH CONTRACTION

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AIM: The Fusion Index (FI) as an index that could easily evaluate tetanic progression in skeletal muscles was proposed (1). In this study, the relationship between the starting frequencies of incomplete or complete tetanus which were calculated from the FI-Frequency Curves (FFC) and twitch parameters (CT and RT) was discussed.
METHODS: The FFC of skeletal muscles of 25 rats with different muscle fiber compositions (GC:9, VI:8, SOL:8) was measured by using load cell, and the starting frequencies of incomplete tetanus ($f_{FI10\%}$) and complete tetanus ($f_{FI90\%}$) were calculated. The twitch parameters (CT and $RT_{10\%,\ 90\%}$: the time it takes for the relative force of the twitch to decrease from its maximum value to 10% and 90%, respectively) were also obtained.
RESULTS: Fig.1(a) shows typical twitch waveform of GC, VI and SOL. The duration of the twitch was prolonged in the order of GC, VI and SOL. Fig.1(b) shows the typical force during incomplete/complete tetanus, and the FFC in Fig.1(c) was obtained from (b). Table 1 shows $f_{FI10\%}$ and $f_{FI90\%}$ of FFC, and $1/(CT+RT_{10\%})$ and $1/(CT+RT_{90\%})$ calculated from the twitch waveform. The mean value of $f_{FI10\%}$ and $f_{FI90\%}$ almost significantly increased in the order of SOL, VI and GC. There is a no significant differences between 1/(CT+RT10%) and $f_{FI10\%}$ in incomplete tetanus and a comparison between 1/(CT+RT90%) and $f_{FI90\%}$ in complete tetanus, regardless of fiber composition using the Wilcoxon t-test.
CONCLUSION: The $f_{FI10\%}$ and $f_{FI90\%}$ were approximated from $1/(CT+RT_{10\%})$ and $1/(CT+RT_{90\%})$, respectively. This relationship was not affected by fiber composition.

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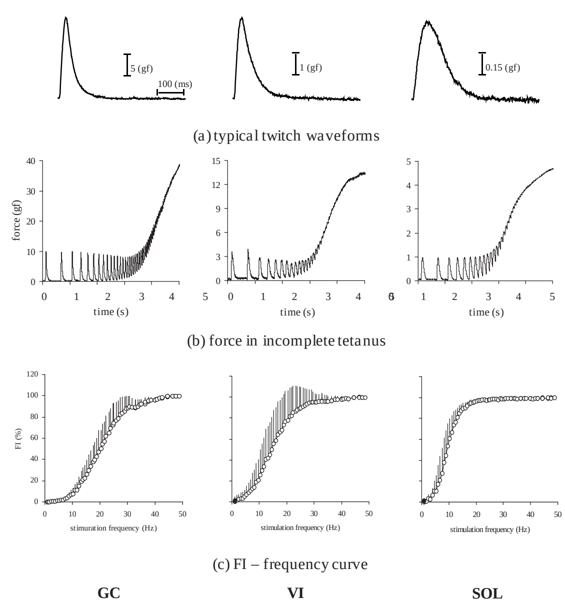

Figure 1: Typical twitch waveforms and force / FFC during incomplete tetanus in the GC, VI and SOL muscles.

Table 1: Frequencies obtained from Fusion-Index Frequency Curve and twitch waveforms.

	FFC		**twitch**	
frequency	$\mathbf{f_{FI10\%}}$	$\mathbf{f_{FI90\%}}$	$\mathbf{1/(CT+RT_{10\%})}$	$\mathbf{1/(CT+RT_{90\%})}$
GC	11.8 ± 2.6 Hz	30.4 ± 4.4 Hz	10.5 ± 2.7 Hz	26.4 ± 3.8 Hz
VI	8.9 ± 4.7 Hz	23.4 ± 7.5 Hz	8.5 ± 3.6 Hz	21.6 ± 5.2 Hz
SOL	4.6 ± 1.4 Hz	14.1 ± 2.5 Hz	4.7 ± 1.1 Hz	11.1 ± 2.5 Hz

SURFACE MECHANOMYOGRAM EVOKED BY TRANSCRANIAL MAGNETIC STIMULATION TO EVALUATE CENTRAL MOTOR CONDUCTION TIME

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AIM: Our goal was to validate the use of surface mechanomyogram (MMG) evoked during transcranial magnetic stimulation (TMS) to evaluate central motor conduction time (CMCT) with reference to those calculated by recording motor evoked potentials (MEP).
METHODS: MEPs and MMGs were recorded in 22 healthy volunteers, from right and left first dorsal interosseous (FDI) and tibialis anterior (TA) with surface electrodes (Alpine Biomed, USA) and an accelerometer (Nihon-Kohden, Japan) fixed over muscle belly. Single-pulse TMS was performed by using a magnetic stimulator (Medpro, Medtronic, USA) connected to a circular coil. CMCT were calculated by subtracting either MEP or MMG onset latencies obtained with TMS performed during voluntary contraction (TMS active) and cervical/lumbar roots magnetic stimulation (MS root).
RESULTS: ANOVA did not show any lateral effect for muscles and recorded signals. During TMS and motor nerve electrical stimulation (MNS) (Figure 1), MMG onset latencies were always significantly ($p<0.001$) longer than those measured for MEP. During voluntary contraction, MEP latencies significantly ($p<0.001$) shortened whereas MMG ones remained unaffected. Surprisingly, MEP and MMG latencies did not differ significantly with MS root except for right TA. Finally, CMCT values (Table 1) calculated with MMG were always higher than those obtained with MEP. Moreover, there was a significant linear regression ($n=86$; $r=0.760$; $p<0.001$) between CMCTs calculated with MMG and MEP.
CONCLUSION: This study demonstrates that MMG recorded during TMS can be used to estimate CMCTs. However, results obtained during root stimulation suggest that widespread activation of agonist and antagonist muscles gives confounding earlier MMG onsets.

Table 1 : CMCT mean values ± 1 Standard Deviation calculated with MEP or MMG.

	Right FDI	Left FDI	Right TA	Left TA
CMCT_MEP	5.7 ± 1.5	5.5 ± 1.3	12.7 ± 2.2	13.0 ± 2.7
CMCT_MMG	8.1 ± 2.1	7.4 ± 3.4	16.8 ± 5.7	17.4 ± 5.7

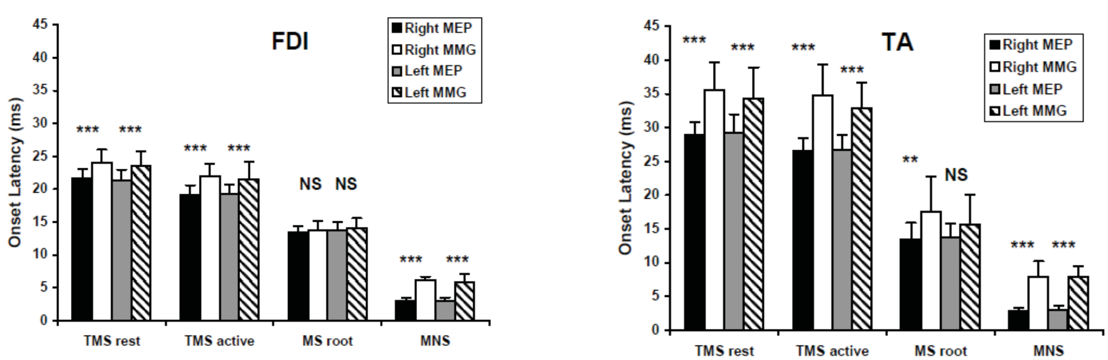

Figure 1: MEP and MMG onset latency mean values + 1 Standard Deviation (***: p<0.001; **: p<0.01; NS: not significant).

POSTURAL BALANCE, NEUROMUSCULAR RESPONSES CHARACTERIZATION IN ELDERLY PEOPLE. EFFECTS OF SEDENATRY CONDITION AND LONG TERM PHYSICAL ACTIVITY

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AIM: The aim of this study was to characterize postural control and neuromuscular responses to long term training exercise and sedentary condition in elderly people.
METHODS: The repeatability of some physiologically significant parameters, calculated during stabilometric tests on a force platform (ProKin, TecnoBody, Bergamo, Italy), was assessed in a previous protocol. Three groups of elderly subjects (average age 67±5 years) were studied: 11 tennis players, 8 long distance runners and 9 sedentary males. The protocol consisted of standard balance tests with eyes open (60 s) or closed (30 s) in bipodalic or monopodalic condition for a total of four recordings for each subject. Finally, one fatiguing contraction of 30 s, and 10 intermittent contractions of 3 s ON + 1 s OFF (80% MVC) were requested on a leg press. These muscular strength tests were associated to surface electromyographic recording from vastus lateralis muscle.
RESULTS: Measurements of the perimeter length and of the velocity of centre of pressure in the anterior-posterior and medium lateral axis, were found to be a simple and reliable way to asses postural stability in elderly subjects (60%<ICC<80%). The comparison between active elderly groups allowed concluding that power trained athletes showed the best balance performance and the greatest MVC values (p<0,01). In fact, Kruskall-Wallis and Dunn's post hoc tests showed a statistically significant difference (34%, p<0,01) between power (148.6±64.8 kg) and endurance (98.4±22.3 kg) groups. No statistically significant differences were obtained between active and sedentary (115.2±40.8 kg) groups.
Continuous resulted more fatiguing than intermittent trials for all subjects (Wilcoxon paired test); normalized slopes of muscle fiber conduction velocity were found respectively: 0.32±0.15 %/s and 0.17±0.12%/s in power group (p<0.05); 0.23±0.21%/s and 0.10±0.10%/s in endurance group (p=0.08); and 0.31±0.13%/s and 0.15±0.10%/s in sedentary group (p<0.05).
CONCLUSION: These findings highlighted the importance of selecting the best exercise modality to compare athletic performances and quantify muscle fatigue. It was concluded that the regular practice of power physical activity increases maximal muscular strength of lower limbs, the stabilometric performance on one leg stance, and thus could reduce the risk of fall. For these reasons it could be suggested and not avoided in the exercise protocols for elderly people.
ACKNOWLEDGEMENT: This work was supported by Compagnia di San Paolo, Torino, Italy and by European Social Fund of the Regione Autonoma Valle d'Aosta, Italy.

EFFECTS OF DIFFERENT SPINAL CURVES ON CARDIORESPIRATORY RESPONSES IN WHEELCHAIR DRIVING

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AIM: It has been reported that gas exchange and cardiorespiratory responses during exercise in different conditions of spinal curve. However, measurements for cardiorespiratoly effects of spinal curve conditions have been studied on walking. The aim of this study was to compare cardiorespiratory responses during wheelchair driving in different two conditions of spinal curve.
METHODS: Subjects were 16 healthy men (mean age 25.2±5.1 years) with no history of orthopedic or cardiorespiratory disease. The subjects were enrolled after obtaining written informed consent. Measurements were compared under two conditions of spinal curve, one was normal and the other was interfered with strap to enhance spinal curve. We investigated respiratory rate (RR), tidal volume (TV), minute ventilation volume (˙,VE), movements of thoracic and abdomen for maximal respiration, and heart rate (HR) on rest, during driving wheelchair and until 20 seconds from onset driving with K4b2 (COSMED). Cardiorespiratory data were measured breath-by-breath with two spinal curve conditions. Oxygen debt (O_2 debt) and Borg scale as rate of perceived exertion (RPE) were also measured. Normal and enhanced spinal curve condition were examined with the paired T-test using SPSS ver16. Differences with $p<0.05$ were considered significant.
RESULTS: In enhanced spinal curve, cardiorespiratory responses were not significantly change at rest. RR of driving wheelchair was significantly increased by enhanced spinal curve, TV and HR during wheelchair driving was no significantly change. TV and ˙,VE were significantly slowed on exercise onset in enhanced spinal curve. In addition, O_2 debt was significantly increased in enhanced spinal curve. Borg scale in enhanced spinal curve was significantly higher than normal spinal curve. It was commonly believed that O_2 debt indicated to initial deficit of oxygen on exercise onset.
CONCLUSION**:** We conclude that cardiorespiratory effect on driving wheelchair in enhanced spinal curve occurred on increased O_2 debt, due to slowed TV and ˙,VE responses on exercise onset.

IMMEDIATE EFFECTS OF SITTING TRAINING ON A TILTING PLATFORM FOR ACUTE STROKE PATIENTS: ANALYSIS OF EMG AND MOTION OF THE TRUNK

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AIM: It is important to improve sitting balance after stroke. Several studies have reported on sitting balance training of stroke patients, however, the effects of sitting position training on a tilting platform are still poorly understood. The purpose of the present investigation was to assess the immediate effects of sitting training on a tilting platform for acute hemiparetic patients through electromyographic (EMG) and kinematic analysis.
METHODS: Two patients with moderate left hemiparesis due to cerebral infarction participated in this study after providing their written informed consent.
Assessment: Subjects sat on a horizontal platform and were asked to move the trunk laterally to the left or right as much as they could, twice on each sides respectively. During this task, we measured bilateral EMG activity of the thoracic paraspinal (TP) and the abdominal external oblique (EO), and the angle of flexion, lateral bending and rotation of the trunk using a flexible-goniomter (Biometrics Inc.) at the eighth thoracic vertebra. Measurements were made before and after the intervention and calculated using TRIAS motion analyzing system.
Intervention: Patients sat without leg support on a platform tilted 10° to the paretic side in the frontal plane. They were asked to move their trunk laterally to the non-paretic side. This task was performed a total of 60 times.
Data analysis: The paired t-test was used to compare the changes after the intervention.
RESULTS: After the intervention, bilateral EMG activities of TP and EO muscles were significantly increased ($p<0.01$) in lateral bending to the affected side. In lateral bending to the non-paretic side, similar results were obtained except for the EO muscle on the non-affected side of body. Although the angle of the trunk showed forward flexion before the intervention, we found a significant decrease in flexion ($p<0.01$) and subjects could keep an upright posture after the intervention.
CONCLUSION: These results indicated that sitting training on a tilting platform could improve EMG activities and lateral trunk control in acute hemiparetic stroke patients.

AGE-RELATED CHANGES IN MUSCULAR FORCE UTILIZATION DURING BALANCE RECOVERY

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AIM: Falling among older adults is a major public health concern. Deterioration of musculoskeletal function in older adults contributes to age-related deficits in balance stability control. Adequate muscle strength in the lower-extremity is essential to the ability to recover a stable upright stance from an unexpected disturbance of balance. However, research question regarding how much joint force is needed and how this relates to a person's functional capacity at specific joint levels remains unresolved. Quantitative assessment of task demands can be combined with the performance capacity profiles resulting from this study to determine the torque demand to capacity ratio (DCR: task demands relative to strength capacity) of an individual. The DCR provides a joint-specific unified scalar quantity representing the balance recovery demand normalized by the maximum muscle strength capacity of an individual. It would indicate whether a person can recover balance and to what extent of his/her maximum capacity is taxed.

METHODS: Sixteen healthy older adults (OA) and young adults (YA) participated in this study. Backward support surface translation with a velocity of 30 cm/s was used to elicit postural recovery responses of the subject when standing. Sagittal plane ankle, knee and hip torques during maximum voluntary isometric contraction (MVIC) of the dominant leg were measured by a dynamometer. Similarly, peak sagittal plane torques during balance recovery from a perturbation were also obtained. The DCRs (peak torque during balance recovery relative to the peak torque at MVIC) were compared between OA and HA groups. Only successful balance recovery trials without taking a step were analyzed.

RESULTS: In the MVIC task, the OA showed a significantly smaller joint torque in ankle dorsi-flexors, knee flexor/extensors, and hip flexors. During the balance recovery after perturbations, no significant differences between groups were found in all 3 joints. However, the torque DCRs of knee and hip joints were significantly higher in the OA when compared to the HA (Fig.1)

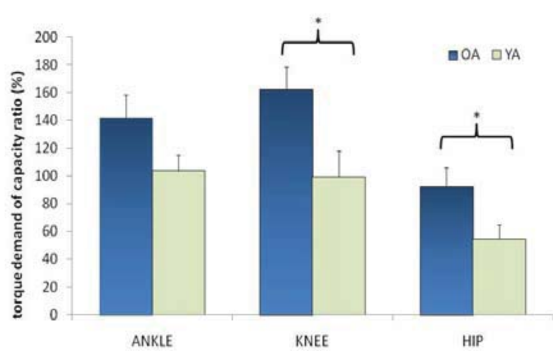

Figure 1: The torque demand to capacity ratio for healthy older adults (OA) and young adults (YA).

CONCLUSION: Even though the healthy OA could produce similar amounts of force as healthy YA when recovered a stable upright balance from an unexpected balance perturbation, the healthy OA needed to use a high muscle strength capacity to accomplish the task. This is the first study which documents the age-related changes in muscular force utilization during balance recovery. Outcomes of this study contribute to clinical application for balance recovery in older adults, as well as provide a basis for developing improved tools for evaluation and treatment of patients with balance disorders.

CHANGES IN MOTOR CORTEX EXCITABILITY FOLLOWING WHOLE HAND VIBRATION

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AIM: To investigate if whole hand vibration in the flutter frequency range (25 Hz) induces lasting post-stimulus changes in the hand region of the primary motor cortex.
METHODS: Healthy subjects (n=11) were chronically stimulated for 20 min by using a therapeutic vibration device (Swisswing BMR 2000). Further a control group was stimulated at the foot sole. Motor evoked potentials (MEPs) after single (recruitment curve) and paired-pulse TMS (SICI, ICF) where recorded from FDI and APB muscles of the right hand. TMS assessments were: pre, post1 (0 min), post2 (30 min), post3 (60 min) and post4 (120 min).
RESULTS: MEP recruitment curves were increased at all post stimulation assessments and for both muscles, see Fig.1. The most significant effect was achieved in post 3 (60 min). SICI was pronounced at post2 and at post3, while ICF also was increased at post4, see Table. No effect was found in the foot-vibration group.
CONCLUSION: Whole hand afferent stimulation by vibration induces lasting plastic changes in the primary motor cortex. Paired pulse stimulation further show that intrinsic intracortial mechanisms are involved because spinal adaptation could be excluded (F-wave assessments). These results could be of relevance for hemiplegic patients with motor deficits, to improve the rehabilitation outcome with vibration stimulation in combination with motor training. As an underlying mechanism somatosenory-mediated disinhibition of motor pathways is in discussion (Kaelin-Lang et al. 2008)
ACKNOWLEDGEMENT: Funded by the Austrian National Bank, Grant Nr. 13221.

Table 1: Paired pulse results (means with standard error).

TMS assessment	**pre**	**post1**	**post2**	**post3**	**post4**
ICI from FDI	0.48 ± 0.08	0.61 ± 0.09	0.64 ± 0.09	0.70 ± 0.11	0.49 ± 0.07
ICF from FDI	1.28 ± 0.01	2.01± 0.29	1.73 ± 0.20	1.98 ± 0.20	1.90 ± 0.20
ICI from APB	0.50 ± 0.05	0.61 ± 0.05	0.71 ± 0.06	0.68 ± 0.07	0.58 ± 0.04
ICF from APB	1.12 ± 0.12	1.60 ± 0.19	1.39 ± 0.18	1.67 ± 0.18	1.74 ± 0.16

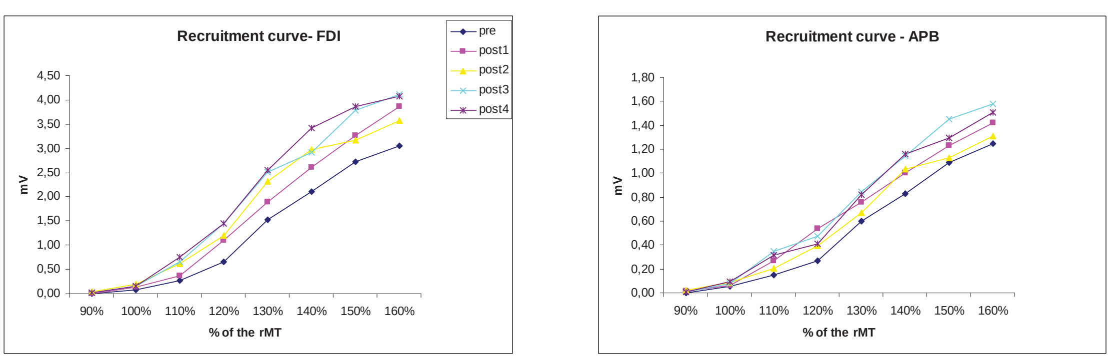

Figure 1: MEP recruitment curves for FDI (left) and APB muscles (right).

HUMAN MOTOR CONTROL: A PERSPECTIVE

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I will present our work to discuss simplifying strategies used to coordinate the movements of limb segments during a variety of tasks. Inter-segmental coordination is a key control property which stems from the coupling of neural oscillators with each other and with limb mechanical oscillators. Muscle contraction intervenes at specified times to re-excite the intrinsic oscillations of the system when energy is lost. Coordinative control results from an active tuning of the passive inertial and visco-elastic coupling among limb segments. I will describe motor programs - assessed from multi-muscle EMG recordings - in terms of characteristic temporal components of muscle activations linked to specific kinematic events. In particular, I will show that muscle activity occurring during several human movements can be accounted for by four to five basic temporal components. The coordination of automatic rhythmic movements (such as locomotion) with voluntary discrete movements may be accomplished through a superposition of motor programs or activation timings that are separately associated with each task. These motor programs are not inborn, but develop progressively with the nervous system maturation, as shown by our recent data gathered on infant locomotion.

THE DYNAMICS OF SITTING IN RELATION TO DISCOMFORT DEVELOPMENT

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AIM: The aim of the present study was to investigate the dynamics of sitting postural movement in relation to the development of perceived discomfort by means of linear and nonlinear analysis.
METHODS: Nine male subjects took part in this study. Discomfort ratings, kinetic and kinematic data were recorded during 90 min partly constrained sitting on a force platform. Body part discomfort index, displacement of the center of pressure in anterior-posterior and medial-lateral directions as well as lumbar curvature were calculated. The mean, standard deviation and sample entropy values were extracted from the center of pressure and lumbar curvature signals. Standard deviation and sample entropy were respectively used to assess the size of variability and complexity of sitting. A correlation analysis was conducted.
RESULTS: There were no correlations between discomfort and any of the mean values ($P > 0.05$). On the contrary, the standard deviation of the center of pressure displacement in both directions and lumbar curvature were positively correlated to discomfort, whereas sample entropies were negatively correlated ($P < 0.05$, Figure 1).
CONCLUSION: This present study revealed that the size of variability and the complexity of sitting postural control are interrelated with perceived discomfort. The importance of the dynamics of sitting control may actually challenge the idea of an ideal seated posture.
ACKNOWLEDGEMENT: The authors are grateful to Søndergaard EK for her contribution to data collection.

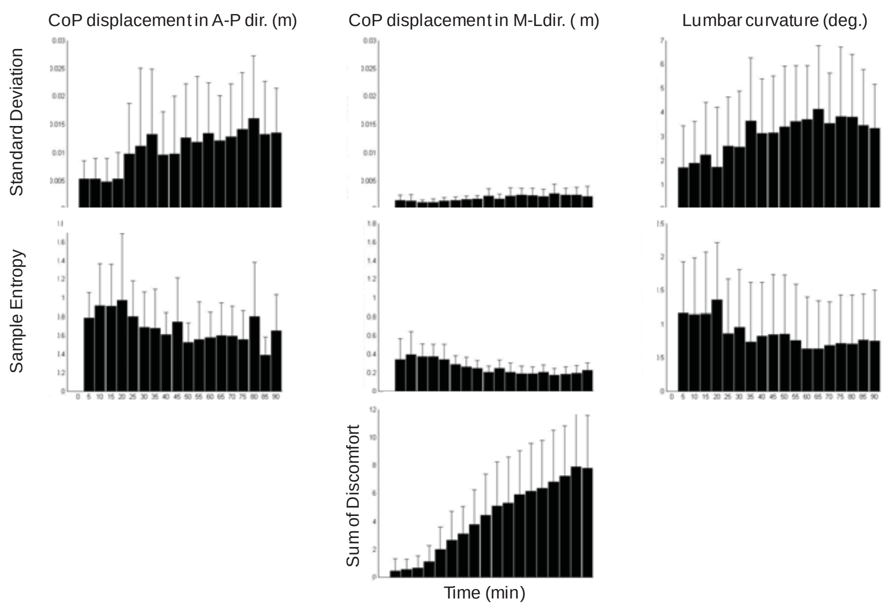

Figure 1: Mean + SD of standard deviation, sample entropy of the center of pressure (CoP) displacement (m) in the anterior-posterior (A-P) and medial-lateral (M-L), lumbar curvature (deg.) and sum of body part discomfort over 90 min seating.

ASSESSING DISCOMFORT, PAIN AND MOTOR ACTIVITY IN WORK-RELATED CONDITIONS

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AIM: The aim of this lecture will be to introduce participants to ergonomic exposure assessment methods for the quantification of discomfort, pain and motor activity in static and dynamic conditions.
METHODS: Techniques for the assessment of discomfort and pain at work will be presented. Focus will be given to possible transition from discomfort to acute pain episodes (endogenous and exogenous) and chronic pain. Further, techniques for the assessment of motor activity such as surface electromyography, mechanomyography, force and movements recordings at work will be reviewed in simulated or real-work conditions (Figure 1).
RESULTS: Relationship between sensory and motor changes will be presented. Similarities and differences of motor changes in response to discomfort, acute pain and chronic pain will be emphasized.
CONCLUSION: The assessed motor responses in presence of discomfort, acute and chronic are helpful to benchmark discomfort and/or pain status. These can in turn be used to develop prevention or rehabilitation programs aiming at reducing the occurrence of work-related disorders.

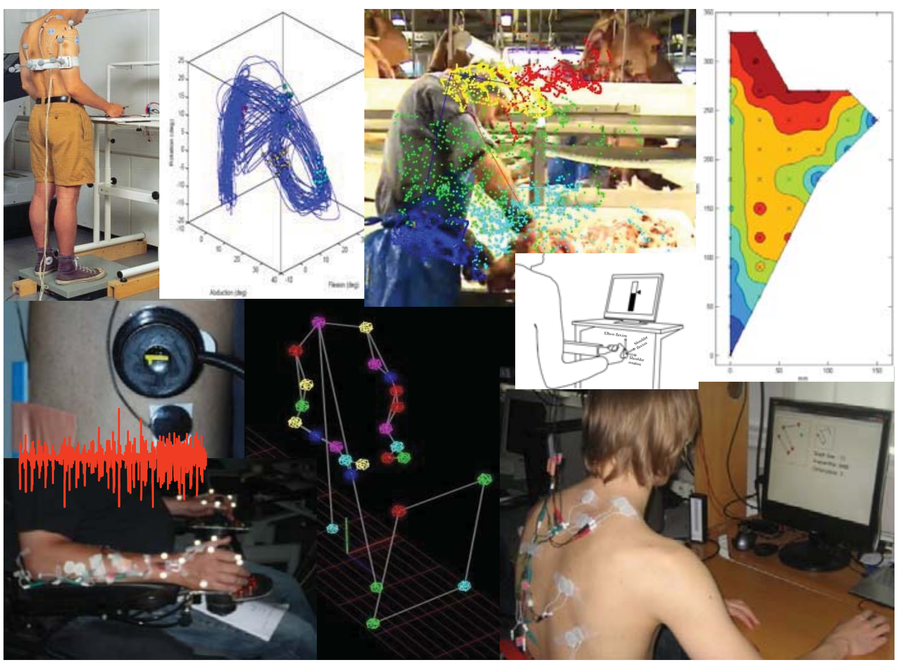

Figure 1: Some of the methods currently used to assess sensory-motor interactions at the Laboratory for Ergonomics and Work-related Disorders, Center for Sensory-Motor Interaction (SMI), Dept. of Health Science and Technology, Aalborg University, Denmark.

EXPERIMENTAL THIGH MUSCLE PAIN IMPAIRS POSTURAL CONTROL DURING QUIET STANDING POSTURE

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AIM: To investigate the effect of leg muscle pain on postural control during quiet standing.
METHODS: This experiment was randomized, blinded, placebo controlled, and included two sessions with at least one week interval in-between. Ten subjects were standing on a force platform. Each session consisted of six trials each of 10 min duration with 10 min interval in-between. The first trial was the baseline recording for the following two trials (during and after experimental pain). In each trial, one minute of quiet standing was recorded. The centre of pressure was calculated from the force platform data, and the displacement and speed of sway in both directions and total sway area were extracted. Bilateral surface electromyography from *erector spinae* (ES) at the 4th lumbar vertebrae level, *tibialis anterior* (TA), *gastrocnemius medialis* (GM), *vastus medialis* (VM), and *biceps femuris* (BF) muscle were recorded. The foot pressure distributions were measured using pressure sensitive insoles. Electrogoniometers on the hip, knee, and ankle joints were used to obtain kinematical parameters. Intramuscular injection of sterile hypertonic saline (0.15 ml, 6% = pain) was used to induce acute pain in the VL, VM and BF muscles separately. One bolus of isotonic saline (0.15 ml, 0.9% = no pain) was injected in VM muscle as control. The order of the injections was randomly assigned and blinded for the subject. Pain was assessed on a 10-cm visual analogue scale.
RESULTS: The experimental pain elicited significantly higher pain than the control injection ($P < 0.01$). Pain in the VL and VM evoked larger sway area and increased medial-lateral centre of pressure displacement and speed compared with baseline ($P < 0.05$). Simultaneously, the left tibialis anterior muscle activation was higher and pain in VL also induced higher activation of the left multifidus muscle ($P < 0.05$). Compared with baseline pain in the VM muscle increased the sway displacement in the anterior-posterior direction ($P < 0.05$). Increased asymmetrical weight distribution towards the non-painful side ($P < 0.05$) and higher activation of the left VM muscle ($P < 0.05$) were found during pain in BF muscle compared with baseline.
CONCLUSION: These findings suggest that the postural control during quiet standing is highly affected by knee extensor muscle pain. The changes were mainly observed in the medial-lateral direction which previously have been correlated with increased likelihood of falling in elderly people. Therefore, clinical approaches to relief pain in the knee extensor muscles should be prioritized to avoid further pain, injuries and falls, especially in elderly populations.
ACKNOWLEDGEMENT**:** The Danish Ministry of Health and Prevention

TETANIC PROGRESSION OF A MECHANOMYOGRAM OBSERVED USING THE SIGMOID FUNCTION

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AIM: The fusion index (FI) measured from muscle force is used to evaluate the tetanic progression of skeletal muscles. The relationship between the FI and stimulation frequency is termed a Fusion Index – Frequency Curve (FFC). The FFC is expressed by the sigmoid function (FFC-equation), which employs 2 parameters (k and h). However, there are no reports on the application of the FFC-equation to mechanomyogram (MMG). In this study, the FFCs of the MMG of the gastrocnemius (GC), vastus intermedius (VI), and soleus (SOL) muscles of rat were measured, and the FFC-equation was applied.

METHODS: The FFCs were obtained for the GC (n = 9), VI (n = 8), and SOL (n = 8) muscles of 25 rats. The muscles were exposed by incising the skin. The peripheral tendons of each muscle were cut off, and then fixed using a pin at the muscle length at which the force was the largest. Electric stimulation was provided using a negative 1-millisecond pulse. The pulse stimulus was applied twice within 2 seconds to obtain a twitch, and a sweep of 1-50 Hz was applied within 5 seconds to stimulate incomplete/complete tetanus. To measure the MMG, a charge-coupled device (CCD) type laser displacement sensor was used, MMG signals were processed by a 300 Hz low pass filter and sampled at 2000 Hz. The FFC-equation was as follows: $FI(f) = f^{h} / (k^{h} + f^{h}) \times 100$, which f is the stimulation frequency, k is the stimulation frequency at 50% of the FI, and h reflects the slope of the FFC, and it was applied to the obtained MMGs. The parameters k and h were determined by the least squared errors method for all measured points of the FFC.

RESULTS: The figure shows typical waveforms of the FFC and FFC-equation in SOL. The root mean squared errors for the fitting were 2.50%±1.13%, 2.61%±1.56%, and 1.92%±1.01%, respectively. The FFC-equation corresponded with the measured FFC very well. In addition, the values of k for GC, VI, and SOL were 19.2±5.7, 11.3±3.4, and 7.3±1.3 Hz, respectively, whereas those for the h parameter were 4.3±1.2, 3.5±0.4, and 4.4±0.7, respectively. Later, k decreased in the order of GC, VI, and SOL, whereas h showed constant values regardless of the fiber composition of the muscles.

CONCLUSION: The FFCs of MMG in rat GC, VI, and SOL muscles were measured, and applied to the FFC-equation. The FFC-equation was found to correspond with the measured FFC of MMG.

ACKNOWLEDGEMENT: This research was partially supported by a Grant-in-Aid for Young Scientists (Start-up) 21800052 from the Japan Society for the Promotion of Science (JSPS).

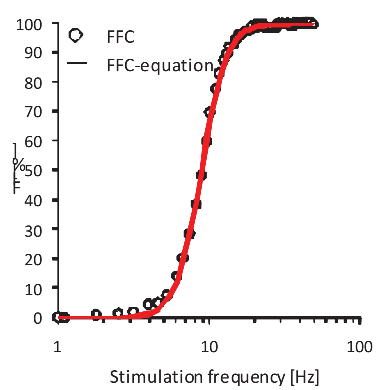

Figure: Typical waveform of FFC and FFC-equation in SOL.

FINGER TACTILE INFORMATION WITH NOISE STIMULATION REDUCES POSTURAL SWAY DURING QUIET STANDING

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AIM: It has been suggested that postural sway is reduced when a fingertip lightly touches a fixed object irrespective of mechanical support (Jeka JJ 1997, Kouzaki et al. 2008). However, neural mechanism of light touch effect on postural control during quiet standing remains to be elucidated. The present study therefore aimed to investigate whether or not finger tactile perception with noise stimulation enhances postural stability.
METHODS: Thirteen healthy subjects (23.7 ± 2.2 year) were asked to maintain quiet standing on a force platform for 30 seconds with eyes closed. Then, the subject' index finger of right hand lightly touched the wooden surface, which was parallel to the floor (LT, light touch). The vertical contact force was required to be < 1N and was monitored by the experimenter. In addition, the surface was vertically oscillated. The vibration was electrically-controlled by a computer and the computer outputted white noise signal with variable amplitude. The amplitude of vibration was adjusted to be 0.5 times of sensory threshold (0.5ST), 1.0ST, and 2.0ST. The ST was defined as the largest amplitude the subject could not sense. In total, each subject underwent five experimental conditions: 1) LT, 2) LT+0.5ST, 3) LT+1.0ST, 4) LT+2.0ST, and 5) no touch (NT, control). Each condition was repeated eight times with randomized order. Center of pressure (CoP) in anteroposterior direction was measured by the force platform and mean velocity of the CoP (CoP total path length per calculated time) was computed for each experimental condition.
RESULTS: Mean velocity of CoP significantly reduced in four light touch conditions (i.e., LT, LT+0.5ST, LT+1.0ST, and LT+2.0ST) when compared with NT condition ($P < 0.05$). Furthermore, the mean velocity of CoP was compared between four light touch conditions. As a result, further significant reduction of mean velocity of CoP was observed only at LT+0.5ST condition ($P < 0.05$), although average value and standard deviation of finger contact force were not different between conditions.
CONCLUSION: The present finding suggests that vertical positional information from finger tactile perception plays an important role in the neural feedback circuit for postural stability. This also implies that stochastic resonance exists in finger tactile perception for vertical positional information.
ACKNOWLEDGEMENT: This study was supported by the Francebed Medical Home Care Research Subsidy Foundation.

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SURFACE ELECTROMYOGRAPHY OF RESIDUAL LIMB MUSCLES IN TRANSFEMORAL AMPUTEES DURING AN ISOMETRIC CONTRACTION

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AIM: The pilot study investigated changes in amplitude and frequency of surface electromyography (sEMG) of five residual limb muscles in transfemoral amputees with osseointegrated prostheses (OPs) and a control group following a maximum voluntary contraction (MVC). Differences in the sEMG between the five muscles were determined for both groups. Clinically, this information is relevant both for selection of a muscle as a myoprocessor and as an indicator of muscle functionality.
METHODS: sEMG was recorded from six transfemoral amputees with OPs and ten control subjects. All the sEMG signals were collected using the Biometrics DataLINK DLK800 system (Biometrics Ltd, Gwent, UK) with a sampling frequency of 1000 Hz, with band pass 25Hz – 460Hz. Muscles selected for measurement were gluteus maximus (GMX), gluteus medius (GMD), rectus femoris (RF), adductor magnus (AM) and biceps femoris (BF). Participants were requested to hold a MVC for five seconds. The mean rectified amplitude (MRA) and variance (VAR) were calculated for the resting muscle and the contracting muscle. The frequency spectrum was estimated by application of the Welch method and the subsequent median frequency calculated for both contracted and relaxed muscle. The change in the three parameters from the resting to contracting state was determined.
RESULTS: All the amputees' muscles displayed an increase in both MRA and VAR (Table 1). A statistical difference was found for this group between muscles for the MRA and VAR change (p=0.029 and p=0.014 respectively). Post -hoc tests revealed a significant difference in MRA and VAR change between GMX and RF (p=0.047 and p=0.041 respectively). No significant difference was found for the MRA and VAR change between muscles in the control group. There was no significant difference in median frequency change both within and between muscles for the control and amputee group.
CONCLUSION: The increase in MRA and variance indicates that ion transfer occurs across the sarcolemma even for those muscles where the amputation may have been performed proximal to the motor end plate. All five residual limb muscles therefore have the potential to contract and exert a force across the hip joint. The small sEMG change recorded in the cleaved muscle RF can be explained by possible disrupted innervation and atrophy of the muscle. Fixation of cleaved muscles in amputees fitted with OPs is weak therefore increasing the risk of muscle atrophy. With regard to myoprocessors, selection of RF as a natural sensor may provide a signal of lower power compared to GMAX.

Table 1: Mean increase in amplitude and variance of sEMG for 5 hip muscles for amputee and control subjects (standard deviation).

MUSCLE	AMPUTEE GROUP		CONTROL GROUP	
	MRA increase (%)	VAR increase(%)	MRA increase(%)	VAR increase(%)
GMAX	**2181 ±1695**	**57620 ± 76496**	**1093 ± 73**	**21303 ± 20078**
GMED	**651± 648**	**8194 ± 16275**	**908 ± 509**	**15188 ± 12107**
RF	**439 ± 198**	**2717 ± 2062**	**525 ±413**	**7131 ± 9985**
AM	**746 ± 610**	**9757 ± 12398**	**902 ± 887**	**23802 ± 39097**
BF	**933 ± 701**	**16321± 23502**	**722 ± 830**	**10316 ± 14784**

THE EFFECT OF BALANCE EXERCISE ON THE TRANSVERSUS ABDOMINIS AND THE MULTIFIDUS -ANALYZED WITH CHANGES IN T2 VALUE ON MAGNETIC RESONANCE IMAGING -

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AIM: On the basis of the importance of postures for prevention of low back pain, there have been many reports in recent years, showing that deep-seated muscles of the trunk play important roles in maintaining proper postures. One method, balance exercise in a sitting position is recognized as an exercise for deep muscles of the trunk. However, since it is difficult to evaluate activities of deep muscles from the body surface, it has not yet been demonstrated as to whether this method is effective for maintenance of postures. To that end, the effect of balance exercise in a sitting position on an unstable plate on deep muscles of the body trunk was analyzed. From the results of the analysis, the efficacy of the exercise was estimated, which was the objective of this study.

METHODS: The subjects were 19 male adults (mean age, 20.5). They were instructed to take a sitting position on an unstable plate[250mm (diameter) X 70mm (height)]. The task given to each subject was to keep balancing for 20 seconds with one raised upper extremity and one raised lower extremity, which was on the opposite side of the upper extremity. Each subject conducted the task alternately, right and left sides, and was instructed to continue the exercise for 20 minutes. MRI was conducted before and after the exercise. The system used was 1.5-T Magnetom Symphony (SIEMENS Inc.). The imaging technique was spin-echo, echo-planar imaging. The time required in taking a picture was assumed to be 12 seconds. T2 was calculated from this predicted signal strength curve. The muscles analyzed were the musculus transversus abdominis (TrA) and the musculus multifidus (MF) and a superficial muscle, the musculus rectus abdominis (RA), as control. A horizontal transverse image of the 4th lumbar vertebra was made for the analysis. The bilateral MR signals were averaged with each muscle, and the mean MR signals pre and post exercise were compared by Two- factor repeated measures ANOVA. The 3 muscles and pre -post were assumed to be within-subject factors. The significance level was designated 5%. This study was conducted with the approval of the Ethics Committee of the Tokyo Metropolitan University.

RESULTS: T2 values for TrA pre-exercise averaged 36.82msec (sd3.66) and those post -exercise 43.60msec (sd4.63). The corresponding values for MF pre-exercise averaged 36.17(1.74) and those post-exercise 39.23(2.21). In contrast, the corresponding values for RA pre-exercise averaged 34.59(4.21) and those post-exercise 32.66(4.07). The 3 muscles, pre-post and interaction showing a significant difference.

CONCLUSION: The T2 value shows response to free water in the tissue. The phenomenon, i.e., the increases in T2 values for the deep muscles post exercise, shows the increase in free water of the muscles. This provides evidence for the presence of muscle activities. Thus, these observations and findings indicated that balance exercise with an unstable plate promotes activities of deep muscles of the body trunk.

Table 1:

Results of Two- factor repeated measures ANOVA

	DF	F value	*p* value
muscle	2	40.65	$p<0.05$
pre-post	1	18.25	$p<0.05$
interaction	2	22.10	$p<0.05$

EVALUATION OF LOWER LIMB MOVEMENT WHILE WALKING USING AN ACCELEROMETER

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AIM: For gait analysis using an accelerometer, the accelerometer is usually attached to the lumbus (L2–3); however, for this study, we attached an accelerometer to the skin over the tibial medial malleolus in order to analyze the movement of the lower limbs exclusively. The aim of this study was to determine the weight borne by and the smoothness of motion of the lower limbs while walking.

METHODS: The study population comprised 22 healthy young men (mean age, 20.2 years [SD, 1.9 years]; mean height, 171.0 cm [2.9 cm]; mean weight, 61.0 kg [8.9 kg]). No participant had any special physical problems. Written informed consent was obtained from all the participants before initiating the study.

A triaxial accelerometer was attached to the subjects' skin over the left tibial medial malleolus. The subjects walked barefoot at their preferred but constant speed (mean 3.9 km/h [7%]) on a floor reaction plate. The same experiment was repeated thrice. The following parameters were calculated: initial peak acceleration (A_v, vertical load; A_p, progressional; A_l, lateral), initial peak floor reaction force (R_v, vertical; R_p, progressional; R_l, lateral), and peak-to-peak acceleration (PPA_v, vertical; PPA_p, progressional; PPA_l, lateral). The mean value for each parameter was determined. The sampling frequency of the accelerometer and the reaction plate was 100 Hz.

The correlation data were analyzed using Pearson's linear correlation coefficient. The gait cycle was analyzed using the fast Fourier transform (FFT) algorithm and root mean square (RMS) analysis.

RESULTS: High linear correlations were observed between A_v and R_v ($r = 0.83$, $p < 0.01$) and between A_p and Rp ($r = 0.70$, $p < 0.01$), measured while walking. A linear correlation was also observed between PPA_l and R_l ($r = 0.53$, $p < 0.05$) measured during the same period. No correlation was observed between the other parameters. The results of the FFT analysis revealed that the data for all subjects exhibited 2 peaks of 20 Hz or less. The mean RMS of 1 gait cycle was 5.07 (SD, 0.09). No significant difference was observed between the RMS values for the 3 experiments.

CONCLUSION: We showed that the accelerometer is clinically effective for gait analysis. A_v represents the quantity of vertical load. PPA_l represents the quantity of progressional perturbation. Gait probably affects the characteristic of the frequency. Therefore, an accelerometer can be used to examine gait and posture. In future, we aim to compare the gait of subjects with a prosthesis or orthosis with that of healthy subjects.

LUMBAR MUSCLE ACTIVITY IN LOW BACK PAIN DURING A HIGH LOAD TRUNK EXTENSION EXERCISE EVALUATED WITH MFMRI: AN EXPERIMENTAL PAIN STUDY.

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AIM: Low back pain (LBP) is often associated with impairment of the lumbar multifidus and erector spinae muscles. A previous study has demonstrated that unilateral muscle pain can cause hypoactivity of muscles during trunk extension at 40% of the repetition maximum. The changes were not limited to the side and level of pain. Moreover, the inhibition was not limited to the multifidus muscle; also the lumbar erector spinae and psoas muscles showed decreased activity during the pain condition. Since this and other studies have mainly focussed on changed muscle recruitment during coordination and low load exercises, a high load exercise was investigated in the current study, to gain insight within the task and load specificity of changes during LBP.
METHODS: Eleven healthy subjects volunteered for this study. They performed a high load dynamic-static trunk extension exercise (at 70% of 1-RM) on a variable angle chair, in a standardized and controlled manner.
Axial images were obtained under 3 different conditions: 1) after rest, 2) after exercise and 3) after exercise with muscle pain. Acute muscle pain was elicited by injection of hypertonic saline in the right longissimus muscle. The left and right erector spinae, multifidus and psoas muscles were analysed at four different levels.
RESULTS: Trunk extension revealed a significant increase in signal intensity compared to rest for the erector spinae and the multifidus muscles, indicating activity of these muscles, whereas the psoas muscle showed no change in signal intensity. Induced muscle pain did not alter the results in comparison to the non pain condition.
These results may be compared with our results of a previous study in which a trunk extension at 40% was investigated since evidence of a linear association between the change of the T2 value and the exercise intensity was provided.
CONCLUSION: This study demonstrates that muscle functional MRI is a valuable technique to evaluate lumbar muscle function during high load tasks. In contrast to low load trunk extension, the current results revealed no difference in lumbar multifidus and lumbar erector spinae activity between a non pain and an induced pain condition. The load specificity of muscle changes may explain this difference.

STUDY OF THE COMPARTMENTALIZATION OF THE HUMAN MEDIAL GASTROCNEMIUS WITH INCREMENTAL M-WAVE: PRELIMINARY RESULTS

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AIM: To test whether the use of multi-channel surface EMG, concurrent with electrical stimulation, allows for rejecting or accepting the hypothesis of compartmentalized motor units in the human medial gastrocnemius (MG) muscle.
METHODS: A grid of 128 electrodes (8 x 16 electrodes, rows parallel to the leg) was positioned above the whole MG muscle of three subjects, who stood quietly on a force-plate. Their waist was fixed to a vertical supporting board to suppress spontaneous postural oscillations and, thus, ensure that MG muscle was not activated. Bipolar current pulses were delivered at 20pps for 10 s to the tibial nerve with a pen electrode, hand held. Stimulus amplitude increased at steps of 0.5 s (e.g. for every 10 pulses) from 0 mA to the maximal stimulation amplitude (staircase stimulation), which corresponded to that producing the highest detectable M-wave. For each stimulation level, M-waves were averaged, thus obtaining averaged M-waves for each of the 20 levels of the staircase stimulation. M-waves obtained from consecutive stimulation levels were subtracted, producing the incremental M-waves. Maps of the amplitude of incremental M-wave were created and the localization of such increments was visually inspected.
RESULTS: Detailed results are reported for one subject. M-waves appeared in the proximal MG portion when the stimulation amplitude reached 10 mA. With stimulus of amplitude progressively higher, M-waves emerged in the distal portion of the array as well. Increments in the amplitude of M-waves were distributed locally in the MG muscle, and alternating between its distal and proximal regions. Figure 1 shows the raw incremental M-waves superimposed on maps of amplitude increments, for two consecutive steps. Between the seventh and eighth levels (step seven), increases in the amplitude of M-waves occurred distally (left panel). Such an increase was more evident in the proximal MG portion when considering the step number eight (from level eight to nine, right panel).
CONCLUSION: The amplitude of M-waves augmented locally with the increase in stimulation amplitude. Despite the number of motor units stimulated, the localized M-waves increments are expected to reflect the localization of muscle fibers of single motor units about the primary branches of the tibial nerve.
ACKNOWLEDGEMENT**:** T.Vieira is recipient of a Brazilian doctoral scholarship (CNPq)

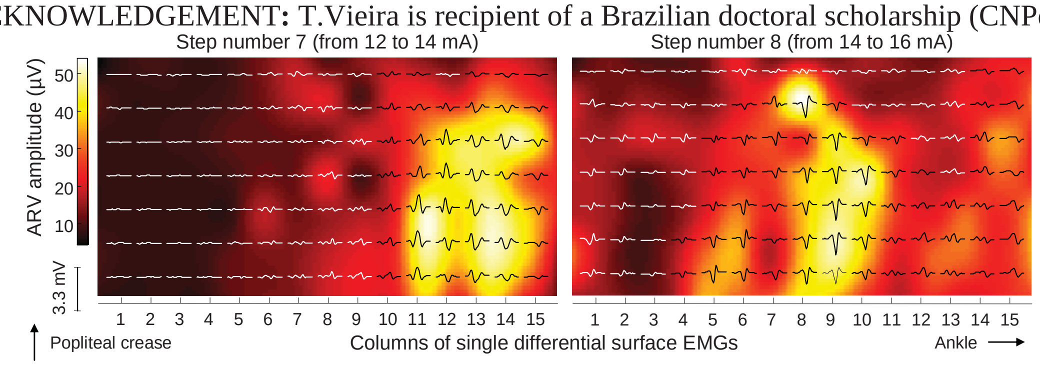

Figure 1: Incremental M-waves and maps of their averaged rectified value (ARV; 15 ms epochs from each stimulus) amplitude for two successive stimulation steps.

LOW-DENSITY HIGH-SURFACE-AREA ELECTROMYOGRAPHY OF THE HAMSTRING MUSCLES DURING DIFFERENT TASKS AND INJURY PRESENTATIONS

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AIM: Low-density high-surface-area electromyography (LDHsEMG) is a non-invasive technique to measure muscle activity with multiple surface electromyography (sEMG) electrodes overlying a target muscle group or limb segment. The collection of both temporal and spatial EMG activity extends the application of traditional sEMG. Initial studies of dynamic movement have been made revealing findings that are representative of the entire muscle and able to track fast changes over the execution of a task.[1] It is known that during terminal kicking, there is primarily an eccentric load on the hamstrings occurring around the hip joint, while during the late stance phase of sprinting the eccentric load is primarily around the knee joint with these actions being associated with tears at corresponding ends of the limb.[2] We hypothesise that the hamstring muscle group demonstrates spatio-temporal activity patterns that are heterogeneous across the muscle surface area but consistent between subjects for given movement patterns. Further we hypothesise that athletes will have injury-specific muscle activation patterns, with reduced muscle activity over the injured area.
METHODS: We will measure LDHsEMG using sixteen channel sEMG during the kicking and running actions in three groups of ten people; controls, athletes with grade two distal biceps femoris tears and athletes with grade two proximal semimembranosus tears at the 6-week post injury stage. Simultaneous motion data will be captured using an active infra-red motion capture system. Diagnosis and injury localisation will be confirmed by clinical examination and magnetic resonance imaging. Movement-registered sEMG data will be analysed using power spectral analysis and compared between movements and between groups.
RESULTS: Sample data is shown in pictorial form for one subject (figure 1). Full results will be available in late April.
CONCLUSION: The novel methods of data collection and analysis will yield useful information about muscle activation of the posterior thigh during different movements and injury conditions.

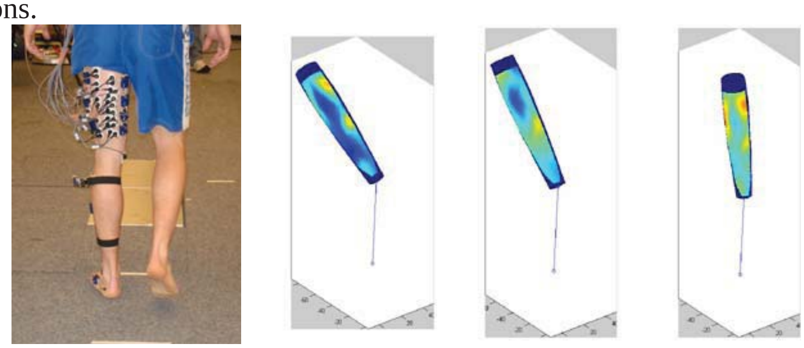

Figure 1: a) Picture to show the experimental set-up on the posterior thigh used in capturing 16 channel sEMG and motion data b) example of movement and sEMG data with false colour topographical map showing non-uniform hamstring muscle activation during different epochs of the gait cycle (low, blue – high, red)

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MUSCLE FIBERS OF INDIVIDUAL MOTOR UNITS ARE SPATIALLY LOCALIZED IN THE HUMAN MEDIAL GASTROCNEMIUS MUSCLE

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AIM: To test whether the muscle fibers of individual motor units (MUs) distribute locally or widely along the human medial gastrocnemius (MG). If muscle fibres distribute locally, then, given the geometry of the MG muscle, we expect its activity to appear locally on the surface.
METHODS: Intramuscular electromyograms (EMGs) were detected with pairs of wire electrodes inserted in three locations along the MG muscle of nine subjects, while standing at ease. 16 surface electrodes were placed aside the percutaneous electrodes, covering the whole muscle (Figure 1). The localization and spread of MUs fibres along the MG muscle were evaluated by fitting a Gaussian to the amplitude distribution of surface triggered potentials.
RESULTS: Action potentials of MUs in the proximal, central and distal locations were recorded only by the most proximal, central and distal surface channels (Top panel of Figure 1 shows one example for a MU recorded in the proximal portion of the MG muscle). The amplitude distribution of surface potentials was significantly centred at 4.40 ± 1.67 cm (mean ± s.d.; N = 11 MUs), 8.02 ± 2.16 cm (N = 19 MUs) and 11.63 ± 2.09 cm (N = 25 MUs) from the position of the most proximal surface channel, when considering the surface potentials triggered with the firing pattern of MUs detected with wire electrodes in the proximal, central and distal MG locations, respectively (ANOVA, $P < 0.001$). About 68% of the area of all Gaussian curves was distributed within ±1cm, indicating the highly localized activity.
CONCLUSION: Muscle fibres belonging to individual MUs were spatially localized in the MG muscle and extended shortly from its proximal to distal region. The pinnated arrangement of gastrocnemius fibres allowed for the selective detection of action potentials of individual MUs from the surface of the skin.
ACKNOWLEDGEMENT: T.Vieira is recipient of a Brazilian doctoral scholarship (CNPq).

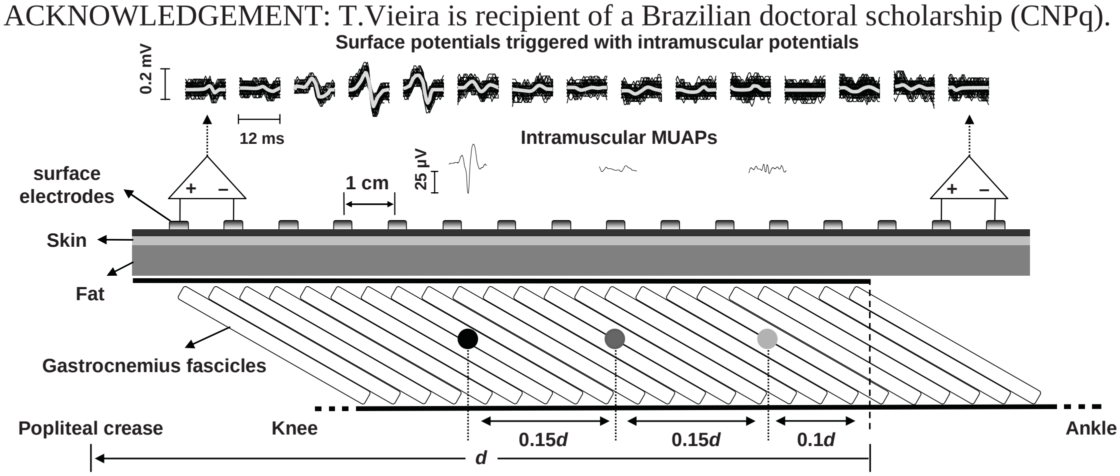

Figure 1: Schematic representation of electrodes positioning (bottom) and the surface potentials (top) triggered with the firing pattern of the motor units identified in the proximal portion of the medial gastrocnemius.

INVESTIGATION OF MONOPOLAR MULTI-CHANNEL SURFACE EMG OF THE EXTERNAL ANAL SPHINCTER MUSCLE

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AIM: This study proposes a new method to investigate the geometry of fibres of the external anal sphincter (EAS) muscle using high density surface electromyogram (EMG).
METHODS: Monopolar surface EMG signals recorded using an array of electrodes placed in circular direction have no common mode (CM) components if the muscle fibres are circular, with constant depth within the muscle and parallel to the detection array. In this case monopolar signals can be estimated from SD signals and compared to the experimental ones. Thus, the presence of CM signals of physiological origin was used to provide indications about the geometry of muscle fibres of EAS. Surface EMG signals were recorded from EAS of 12 subjects (7 females and 5 males) using an anal probe carrying three arrays of 16 electrodes. Single motor unit (MU) discharge times were identified from EMG signals obtained with these arrays and were used as triggers to compute the average action potential of each MU. The amount of CM was estimated from each MU action potential (MUAP) and was analyzed with respect to the radial depth of the MU (estimated by the CoV of the MUAP amplitude in the three arrays) and to the MU position along the anal canal (indicated by the array with higher potential amplitude). The estimation error of each monopolar MUAP was computed as the difference between the original monopolar signal and the reconstructed signal (ARV_e) normalized w.r.t. the original monopolar signal (ARV_m).
RESULTS: The contribution of CM components to single MUAPs is lower for MUs located more superficially in the muscle and at a lower depth within the anal canal.
CONCLUSION: Presence of low CM voltages on MUAPs is related to the geometry of the fibres that, as confirmed by anatomical studies, are circular and parallel to the detection array only at low radial depth within the muscle and along the anal canal. Large CM components are present on MUAPs from MUs located deeply in the muscle or more internally along the anal canal. Moreover, large CM signals are also present in the interference EMG, suggesting that there is crosstalk from far and large co-contracting muscles (e.g. puborectalis, glutei) or deeper MUs with non-cylindrical geometry.
ACKNOWLEDGEMENT: This work was sponsored by Projects TASI (Else Kroner-Fresenius-Stiftung, Compagnia di San Paolo), and TIFNI (Regione Piemonte, Italy).

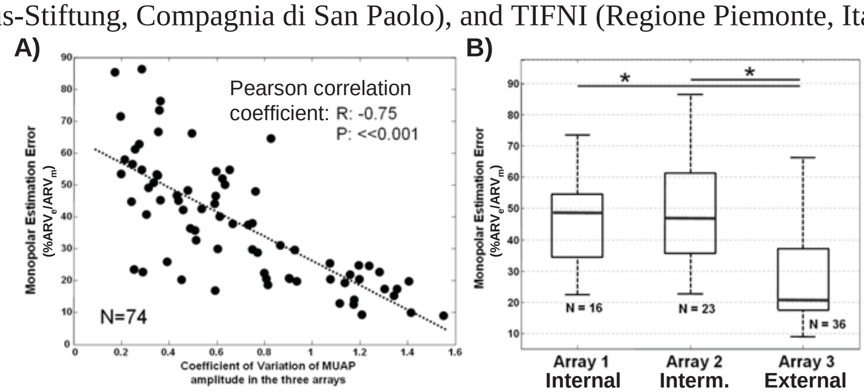

Figure 1: A) Scatter plot of the monopolar estimation error versus the coefficient of variation of MUAP amplitude in the three arrays. B) Monopolar estimation error of MUAPs with higher amplitude in one of the three arrays. ARV = Average Rectified Value.

DESIGN AND DEVELOPMENT OF A DISPOSABLE RECTAL PROBE FOR HIGH-DENSITY MULTI-CHANNEL SURFACE EMG OF THE EXTERNAL ANAL SPHINCTER MUSCLE

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AIM: Recent studies demonstrated that a significant correlation exists between tissue lesions which occur during natural childbirth, either spontaneous or induced (episiotomy), and subsequent appearance of fecal incontinence in women. Knowledge of the location of the innervation zones and of the anatomy of the anal sphincter will allow avoiding such zones during episiotomy with expected significant reduction of the consequences of this surgery. After demonstration of the feasibility of EAS investigation through EMG rectal probes designed for research purposes, it became evident that arrays with more than 16 contacts were needed to study individual motor units, and disposable low-cost probes would be required by the market. The aim of this work was to develop a low cost disposable rectal probe which allowed the detection of high density electromyography from the external anal sphincter.
METHODS: The device developed for this purpose is constituted of: 1) Electrical circuits with one silver electrode array printed on flexible plastic film, 2) A plastic support with a conic portion in the central part of the body. The plastic flexible circuits are wrapped and glued around the plastic support creating a cylindrical probe with one or more arrays of electrodes (Figure A).
RESULTS: The probe was tested on seven patients allowing the identification of single motor units by means of a surface EMG decomposition algorithm (Holobar and Zazula. 2004). The analysis of EMG signals recorded with this probe allowed the evaluation of the innervation zone distribution and the computation of EMG amplitude maps of the sphincter muscles.
CONCLUSION: Low-cost, disposable e minimally invasive EMG probes will enable preventive screening on every pregnancy to minimize the risk of episiotomy.
ACKNOWLEDGEMENT: This work was sponsored by Projects TASI (Else Kroner-Fresenius-Stiftung, Compagnia di San Paolo), and TIFNI (Regione Piemonte, Italy).

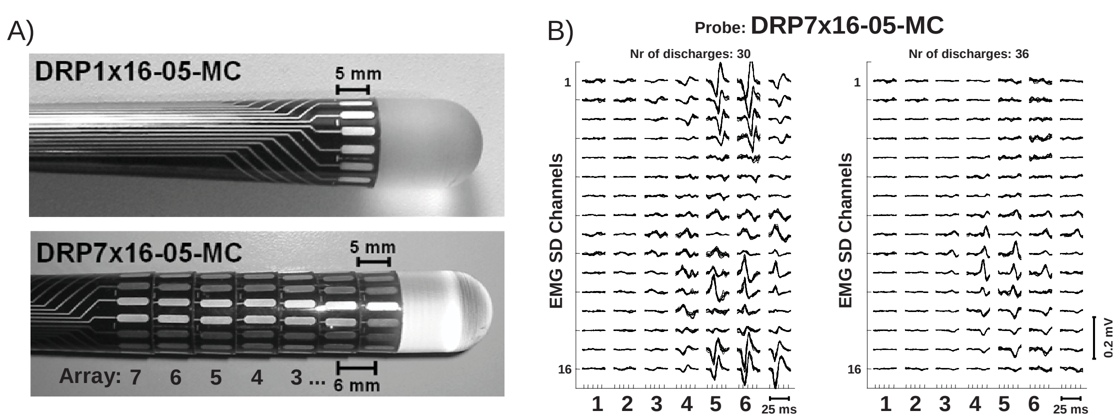

Figure: A) Two examples of probes with one and seven 16-electrode arrays are shown in the right panel (DRP1x16-05MC and DRP7x16-05MC). B) Templates of two motor units identified in the sEMG detected with the DRP7x16 05 SB probe during a maximal contraction of the sphincter. The subject is a 64 years old female.

NEURAL ADAPTATIONS TO ELECTRICAL STIMULATION STRENGTH TRAINING

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Neuromuscular electrical stimulation (ES) involves the application of intermittent stimuli to superficial skeletal muscles, with the principal aim to evoke visible muscle contractions. ES is largely adopted as a rehabilitation tool and as a strength training modality, despite limited evidence for effectiveness. In a recent systematic review of quadriceps ES training studies, Bax et al. (2005) suggested that for unimpaired muscles the effectiveness of ES appears to be lower compared to voluntary training programs. On the other hand, ES training could be more effective than volitional training modalities for the quadriceps muscle recovering from partial or complete immobilization (Bax et al. 2005).

In the presence of ES-induced strength gains, a series of training studies have provided compelling evidence of neural adaptations induced by short-term ES programs, mainly on healthy muscles. These adaptations include: (1) significant increases in maximal voluntary strength after only a few sessions of ES (McMiken et al. 1983), when there is no reason to believe that increased protein synthesis could have induced significant muscle hypertrophy; (2) strength increases without any significant changes in muscle enzyme activity, fiber size, or mitochondrial properties (Eriksson et al. 1981; see Cabric et al. 1988 for a contrary view); (3) voluntary strength gains of the contralateral homologous muscle after unilateral training (i.e., cross-education effect) (Hortobagyi et al. 1999); (4) increases in voluntary muscle activation as measured with surface electromyography (Maffiuletti et al. 2002), twitch interpolation (Stevens et al. 2004), and the amplitude of the volitional (V) wave (Gondin et al. 2006). Surprisingly, ES training does not seem to influence H reflex excitability (Gondin et al. 2006), both at rest and during an actual contraction, so that it has been inferred that ES training-induced adaptations would be mainly located at the supraspinal level.

The time course of neuromuscular adaptations to ES strength training appears similar to the classical model proposed by Sale (1988) for voluntary strength training. In fact, Gondin et al. (2005) demonstrated that 4 weeks of ES significantly increased maximal voluntary strength and voluntary activation, while muscle cross-sectional area was not significantly altered. After 8 weeks of training, both neural and muscular adaptations mediated the strength improvement induced by ES.

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ESTIMATION OF MUSCULAR COORDINATION, MUSCLE FORCE AND FATIGUE THROUGH MULTICHANNEL OR HDEMG

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The estimation of the force generated by an activated muscle as well as the assessment of the underlying coordination of different muscle groups is of high relevance not only in biomechanical studies but more and more also in clinical applications. Here, the information about the muscular co-ordination and the generated muscle forces supports the physicians' decisions on diagnosis and treatment. Multichannel-EMG recorded synchronously from different muscles or muscle groups has become a common tool to detect the muscular coordination pattern during movements. In combination with highly sophisticated biomechanical models an estimation of the generated muscular forces seems to become feasible. However, the interpretation of the detected muscular coordination pattern is often difficult since secondary effects like e.g. crosstalk might mask the observations. Additionally, indirect measurement of muscle force goes along with other unpredictable factors which influence the detected force but not necessarily the sEMG data or the sEMG data and not directly the force. One of these is muscle fatigue. Here, HDEMG yield some additional information which might help to understand the mechanisms of muscular fatigue and their consequences for the detected EMG signals.
This paper aims to give some perspectives how the limitations in the estimation of muscular coordination and force could be overcome especially in clinical applications by using novel ways of interpretation based on multichannel and HDEMG. Especially a method will be introduced which allows a prediction of the risk for cross-talk by fuzzy logic (Figure 1). Furthermore it will be shown, how fuzzy logic can support the interpretation of the muscular co-ordination pattern measured by surface multichannel EMG (Figure 2)

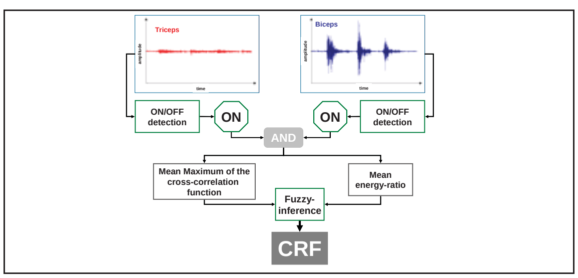

Figure 1: Calculation of the Crosstalk Risk Factor CRF as an individual variable, which reflects the probability for the occurrence of crosstalk individually for each subject. [Disselhorst-Klug, Clin. Biomech., 2009]

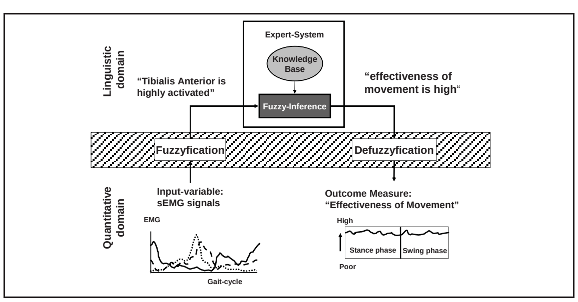

Figure 2: Expert-system based on the fuzzy-inference-method, to support the interpretation of the muscular co-ordination pattern during dynamic movements. [Schmidt-Rohlfing, J Orthop Res., 2006]

A ONE-VERSUS-ONE CLASSIFIER FOR IMPROVED ROBUSTNESS OF MYOELECTRIC CONTROL

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AIM: The development of pattern recognition based myoelectric control systems has historically been governed by a desire for high classification accuracies. However, this accuracy is only defined for exemplars from known classes while active prosthetic use invariably produces extraneous contractions. In this work, a leave-one-out comparison method is introduced to simulate this scenario and is demonstrated using several popular classifiers. A novel multi-expert one-versus-one classification scheme is shown to outperform all examined classification algorithms using both the standard classification accuracy and the modified method.
METHODS: Twelve classes of myoelectric data were recorded from 12 bi-polar electrodes placed circumferentially around the forearms of ten normally limbed subjects. Classifiers were trained and tested using a leave-one-out approach in which an untrained class was included in the test data, but labeled as no motion, in order to test each classifier's ability to reject unknown data. Results were compared using classification error and active error (the error for decisions that would result in motion of the prosthesis). The proposed one-versus-one classifier consisted of N×(N-1) binary classifiers (where N is the total number of classes) which determined the most probable output between each pair of classes. These outputs were subsequently combined to produce a final output which included the ability to default to no motion in case of confusion.
RESULTS: Results from all combinations of subsets were averaged to produce a single output for each classifier type. The resulting classification and active errors are shown in Figure 1.
CONCLUSION: Most of the observed classifiers offered no inherent ability for rejection, as demonstrated by higher active errors than overall errors. The MBC showed an ability to reject unknown active data but at the expense of an overall reduction in accuracy. The proposed one-versus-one (1vs1) classifier showed an ability to reject unknown active data, while also providing better overall classification than all other tested classifiers.

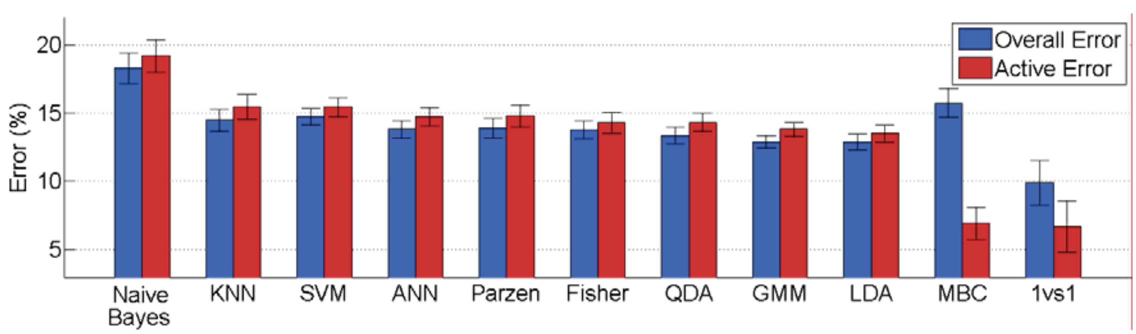

Figure 1: Classification and active errors of classifiers using leave-one-out analysis

CONTRIBUTION OF MUSCLE FIBER COMPOSITION TO FFC-MMG IN MUSCLE TRAINIG/FATIGUE

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AIM: The fusion index (FI)–frequency curve (FFC) of displacement mechanomyogram (MMG) was measured before/after muscle exercise. In this paper, the contribution of muscle fiber composition to the FFC was discussed in muscle training/fatigue.
METHODS: In the muscle fatigue, three subjects (22-55 years old) kept 80%MVC until they were exhausted. In the muscle training, the subject kept the isotonic exercise at about 30% MVC for thirty weeks. The displacement MMG was measured on the biceps brachii (BB) by using a laser displacement transducer under isometric contraction. In the electrical stimulation, a negative pulse of 3ms duration was applied to the motor point through the skin surface. The stimulation frequency was logarithmically increased from 1 to 50 Hz and the stimulus level was set at the value that ignited all MUs. This study was approved by the ethical guidelines for clinical studies of Okayama University.
RESULTS: The measured tetanic progression was quantified using the FI. These FFCs closely resembled an S-shaped curve, respectively. The FFC was expressed by the sigmoid function with two parameters, *k* which was the stimulation frequency at 50% of the FI, and *h* which reflected the slope of the FFC. Figure 1 shows the FFCs in muscle training (a) and isometric muscle fatigue (b). In the muscle training, both *k* and *h* of the sigmoid curve increased after the training, and this was induced from the twitch waveform of shorter contraction / relaxation time caused by the trained FF/FR-MU. On the other hand, *k* and *h* decreased after the fatigue, and this was also induced from the twitch waveform of longer contraction / relaxation time caused by the fatigued FF/FR-MU.
CONCLUSION: In muscle training/fatigue, two parameter *k* and *h* of FFC increased / decreased, and it could be explained by the contraction / relaxation time of twitch waveform of FF/FR-MU.

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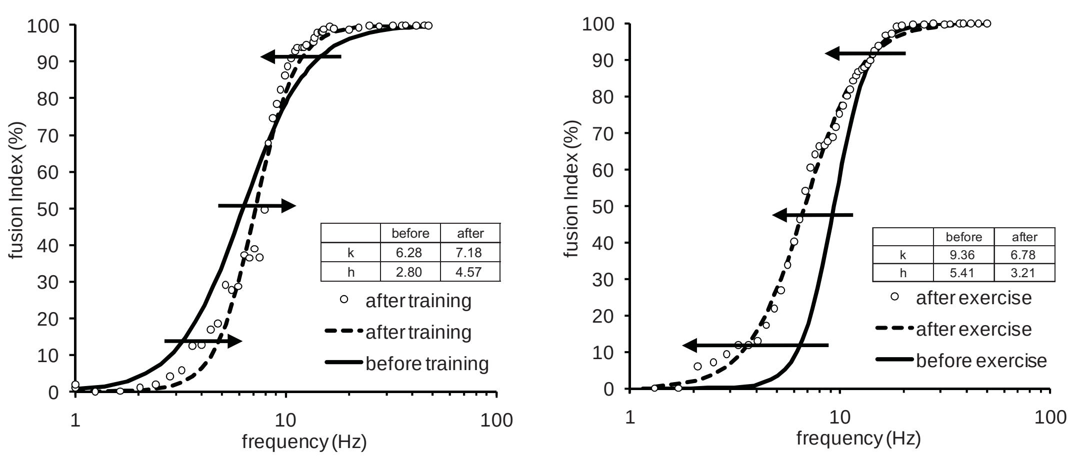

(a) muscle training (b) isometric muscle fatigue

Figure 1: Typical FFCs in muscle training / fatigue.

INVERSE RELATIONSHIP BETWEEN THE COMPLEXITY OF FOOT KINEMATICS AND MUSCLE ACTIVATION IN PATIENTS WITH MEDIAL TIBIAL STRESS SYNDROM

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AIM: In this study, we compared the structure of complexity in foot kinematics and EMG-signals obtained from m. soleus and m. tibialis anterior during walking between patients with medial tibial stress syndrome (MTSS) and a healthy control group.
METHODS: Fourteen patients diagnosed MTSS and 12 healthy controls were sequentially included from a local orthopedic clinic. MTSS was defined as continuous or intermittent pain in the tibial region, exacerbated during repetitive weight bearing activity, and localized pain detected by palpation along the distal two thirds of the posterior medial tibia. EMG signals were recorded from the m. tibialis anterior and m. soleus using the recommendations of SENIAM project (Surface Electromyography for the Non-Invasive Assessment of Muscles). EMG signal corresponding to the swing phase from the gait cycle was excluded from the EMG analysis. Twenty consecutive gait cycles of EMG and kinematics were recorded while subjects were walking on a treadmill at a self-selected pace. The number of gait cycles along the whole recording time was in the EMG data divided into 4 intervals representing (0-25-50-75-100%) of the contact time. The EMG signal in each interval were digitally band-pass filtered (Butterworth, 2nd order, 10-400 Hz) and a notch filter (2nd order Butterworth band stop with rejection width 1 Hz centered at power line frequency (50 Hz)) was applied. A custom 3D multi video sequence analysis procedure was employed to assess midfoot and rearfoot kinematics during the stance phase of walking. In midfoot and rearfoot kinematics the stance phase was extracted from the gait cycle and divided into 1 interval representing (0-100%) of the stance phase. Permuted sample entropy (PeSaEn) (Bandt, C. 2002) was used as a measure of complexity of the time series from the EMG data and kinematic data. Two-way ANOVA was applied for PeSaEn values introducing time and subject groups (healthy, MTSS) as factors in analysis of EMG data. $p<0.05$ was considered significant.
RESULTS: The results showed that the EMG signal from both the m. soleus and m. tibialis anterior in patients with MTSS was characterized by higher structural complexity than healthy controls ($p<0.001$). The opposite was found in midfoot and rearfoot kinematics. The kinematic data from subjects with MTSS was characterized by a lower structural complexity than healthy controls ($p=0.01$). The higher complexity or lower predictability found in MTSS patients corresponds to a lower degree of regularity in the EMG signal but a higher degree of regularity in midfoot and rearfoot kinematics.
CONCLUSION: The present results indicate that non-linear analysis is of relevance for the interpretation of the time series from EMG signal and kinematics time series. Subjects with MTSS who have pain in the tibial region are characterized by higher complexity of EMG signal of the m. tibialis anterior and m. soleus, but lower complexity in midfoot and rearfoot kinematics. Future studies should investigate (i) if higher complexity of EMG data or kinematic data is associated with greater risk of overuse injuries such as MTSS and (ii) if the inverse relationship between the structural complexity of kinematics and muscle activation change after rehabilitation.

ON THE RELATIONSHIP BETWEEN THE ELECTRICAL ACTIVITY OF MYLOHYOID MUSCLE AND THE PRESENCE OF “BROKEN MIRROR NEURONS” IN AUTISTIC INDIVIDUALS

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INTRODUCTION: Recent studies claimed that Autism Spectrum Disorder (ASD) is due to a Mirror Neuron dysfunction (MN). A recent study showed different Electromyography (EMG) trends in Mylohyoid muscle (MH) during grasping-to-eat action between ASD children and Typically Developing (TD) ones [1]. The experiments which led to this conclusion were re-analyzed. We also tested an opto-kinetic system to retrieve the movement of the mouth; the purpose is to evaluate the possibility to avoid using EMG in order to reduce disturbing effects in the experiments (e.g. wires, electrodes, etc.).
METHODS: We used the experimental protocol and data processing proposed in [1]. The MH activity was firstly recorded with surface EMG. Then the experiment was repeated and recorded with a HD camera and markers to measure the span of children’s mouth.
RESULTS: In our experiments it is not possible to distinguish between TD children [2] and ASD ones [3] (see Fig. 1, left panel) using the parameters stated in [1]. In fact, according to [1], TD children should start opening their mouth before touching the food: our TDs does not show this trend. Early opto-kinetic trials show good trend comparison with the EMG data.

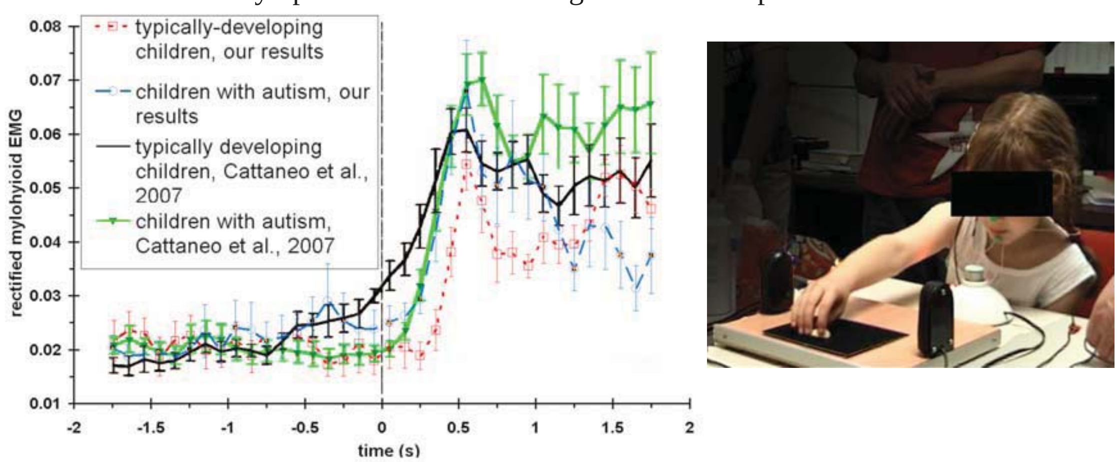

Figure 1: Left Panel: experiment results comparison. Time zero: touching the food. Right panel: frame showing the experimental apparatus and some opto-kinetic markers.

CONCLUSION: the results of our experiments clearly show that the experimental protocol in [1] cannot be used to relate ASD with “Broken Mirror Neuron System”. Further experiments with opto-kinetic instrument will be carried out.

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EVALUATION OF THREE STRATEGIES FOR SIMULATING MOTOR UNIT MUSCLE FIBRE DENSITY

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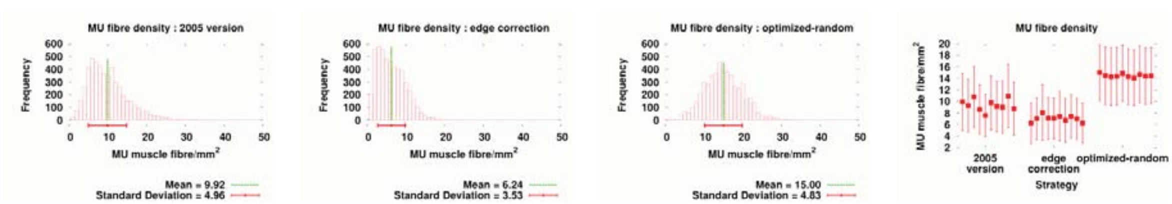
AIM: To evaluate differences between motor unit fibre densities produced by an earlier muscle simulation model [1] and the best strategies evaluated in [2].
METHODS: Muscles were laid out using three strategies: the algorithm described in [1]; this algorithm modified to correct for edge effects as indicated in [2]; and using the full muscle layout algorithm proposed in [2]. Ten muscles were simulated using each strategy. For each muscle, 5000 localized fibre density estimates were calculated by randomly placing a $2mm^2$ circle on the muscle cross section and tallying, of the fibres covered, the number of fibres associated with each MU. The resulting distribution of fibre assignments were then examined to determine if the algorithmic changes suggested in [2] regarding edge effects resulted in significantly different and improved fibre density distributions.
RESULTS: Using ANOVA to examine the distributions of fibre densities showed that, at a 95% confidence level, all three strategies produced fibre density distributions that were significantly different from each other ($p < 0.001$). As Fig. 1(d) shows, the strategy described in [2] (termed Optimized-Random) produces much more consistent, density numbers than the earlier strategy; further, incorporation of a strategy to ameliorate the effect of MUs falling at the edge of the muscle decreases the observed fibre density numbers overall when applied to the 2005 algorithm. Sample distributions for single muscles are shown in Fig. 1(a-c).
CONCLUSION: The overall muscle strategy suggested in [2] provides a significantly different distribution of muscle fibres as measured by the randomly-placed circle sampling technique, however the edge effects noted in [2] are not the major contributing factor to this difference, as incorporation of a correction for edge effects moves the distribution of fibres produced by the unmodified algorithm of [1] farther away from the distribution seen in [2].



a b c d

Figure 1: Observed fibre densities by strategy. Parts (a-c) show original, edge effect modified and optimized-random; part (d) shows comparison across muscle simulations.

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MICROCIRCULATION AND AUTONOMIC FUNCTION ALTERNATION FOR SUBJECTS WITH MECHANICAL NECK DISORDER

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AIM: Mechanical neck disorder (MND) is increasingly prevalent in spinal disorders in our modern lifestyle. It has been reported that about 17-22% of recurrence per year occurred in United States. MND is featured clinically such as symptoms of neck pain, headache, dizziness and limited range of motion. The possible reasons for increased prevalence may result from increased time spending on the table work or the use of computer. Therefore, increased neck extensor muscle tone may affect function of the autonomic nervous system, which is possible factor to lead to prolonged symptoms. The purposes of this study were to investigate any neurophysiologic alternation in subjects with MND.
METHODS: Forty participants were recruited to classified into two groups, 13 were healthy control group and 27 were as MND group. Electrocardiograph was used to determine the heart rate variability (HRV) for subjects at different cervical spine positions. Meanwhile, laser doppler flowmetry (LDF) was used to monitor their effects on the microcirculation under different cervical positions.
RESULTS: MND group had more significantly increased myogenic activity and decreased heart activity in LDF during all cervical movement. In addition, MND group had significantly increased HF% and decreased LF/HF ratio in HRV in rotation to right both in neutral and full flexion positions.
CONCLUSION: Individuals with abnormal head and neck posture for a long period could affect their functions of autonomic nervous system or the circulatory system. Furthermore, these findings may provide in-depth knowledge for clinicians to classify the possible etiology of MND and possible interventions for people with MND.
ACKNOWLEDGEMENT: We would like to thank the financial support from National Health Research Institutes, Taiwan, NHRI-EX97-9713EC.

REMOVING ECG CONTAMINATION FROM EMG SIGNALS USING INDEPENDENT COMPONENT ANALYSIS

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AIM: EMG recordings of trunk muscles are often contaminated by ECG. Especially analysis of relatively low-level activity, such as in studying trunk postural control, may be hampered by this contamination. The aim of the present study was to develop and test a method for removal of ECG contamination from a set of EMG signals of trunk muscles.
METHODS: Thirteen subjects performed semi-static postural tasks, aiming at a target object with a cursor that responded to 2D trunk angles. EMG signals of 4 bilateral abdominal and 4 bilateral back muscles were recorded.
Heart rate was estimated from the mean of the 16 EMG signals by mere peak detection after 8-18 Hz band-pass filtering. Subsequently principal and independent component analysis (PCA and ICA, respectively) were performed on all raw EMG signals, the latter using the fastica algorithm [1]. All components that showed peaks close to the estimated heart rate were identified. The signals were then reconstructed through weighted superposition of the remaining principal or independent components. The results were compared to filtering using a 30Hz high-pass FIR filter [2].
RESULTS: As can be appreciated in figure 1, ICA based filtering removed ECG peaks without apparent loss of information. In contrast, neither the PCA based filtering nor the 30Hz high-pass filter, did completely remove the ECG peaks.
CONCLUSION: ICA based filtering of a set of trunk muscle EMG signals is an effective way of removing ECG contamination.

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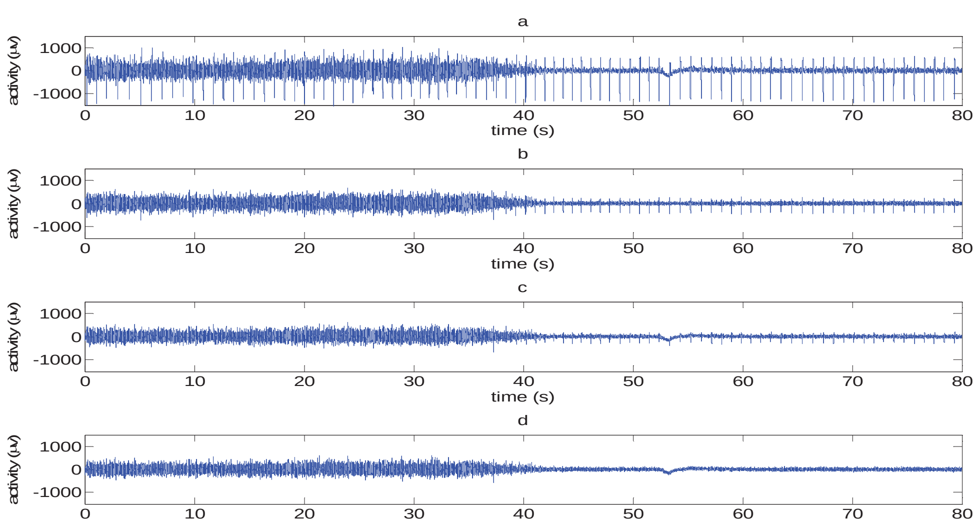

Figure 1: Example of a raw EMG signal of the left m. longissimus thoracis (a), same signal after 30 Hz FIR high-pass filtering (b), after PCA (c) and after ICA (d) based ECG removal. The subject started in a 20^{o} trunk flexion posture, moved towards the neutral posture around 40 seconds and maintained this neutral posture during the rest of the trial.

EFFECT OF TRUNK MOTION ON CALF RAISE STRATEGY

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AIM: The various balance test and scale are used to measure patient's dynamic balance ability in clinical settings. However, these balance test and scale are not clear whether the balance strategy affects the association between score and dynamic balance. Various body functions affect dynamic balance strategy. The purpose of this study was to investigate the effects of trunk immobilization on dynamic balance in calf-raise strategy.
METHODS: Seven healthy young adult males performed calf-raise as high as possible without losing balance in different two condition: no limitation (control) and trunk immobilization by hard brace (brace). The kinematics was recorded with a Vicon motion system. We measured center of mass as follows: 1) total body (COM); 2) head, arm, and trunk (COM_{HAT}); 3) lower leg (COM_{LE}). We compared the distance of respective parameter in two conditions and then the distance in the sagittal plane between COM_{HAT} and COM_{LE}.
RESULTS: The distance of COM_{HAT}, COM_{LE}, and COM were no significant differences between the two conditions. On the other hand, the distance between COM_{HAT} and COM_{LE} in sagittal plane was significantly longer in brace condition than that of control.
CONCLUSION: Our findings suggest that trunk immobilization affects the dynamic balance in calf-raise strategy, especially the distance between COM_{HAT} and COM_{LE} in sagittal plane. The posture of the trunk in the sagittal plane associates with functional performance in calf-raise strategy.

SHOULDER STRENGTH IN DANISH F-16 PILOTS: EFFECTS OF A 24-WEEKS TRAINING PROGRAM

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AIM: Shoulder pain is a common complaint among fighter pilots. Due to the ergonomics in the F-16 where the pilot has to give continuous steering input through a joystick on the right-hand side in the cockpit, problems show predominantly in the right shoulder. We introduced a training program as a part of the pilot's normal daily life and environment with the aim to analyze whether it is possible to specific increase the pilot's shoulder Maximal Voluntary Contraction (MVC) and estimate the correlation between shoulder abduction with slow and rapid onset. The pilots were supplied with training equipment that made it possible to carry out the program at work, at home or abroad.
METHODS: The study was carried out as a randomized controlled trial. After baseline measurements 55 pilots were randomized to either 24 weeks of strengthening training 3x20 minutes a week (n=27) or control (n=28). MVC measurements of shoulder abduction, arm abduction, body flexion and extension and handgrip were sampled at baseline and after the intervention period. Shoulder abduction was tested with slow as well as rapid onset and Rate of Force Development (RFD) was measured in the dominant shoulder. In the RFD-trials participants were instructed to press as hard and quickly as possible against the transducers from a sitting position without foot support.
RESULTS: Rapid MVC of the dominant shoulder increased significantly in the training group with 9.4% from 90.5kp to 98.9kp (p=0.02) but remained unchanged in the control group (86kp; p=0.958). With slow onset the increase in strength did not reach significance in neither of the groups, but the tendency towards increase was stronger in the training group. Shoulder RFD was significantly increased by 17% from 429kp/s to 502kp/s in the training group (p=0.005) and in the control group by 15% from 391kp/s to 449kp/s (p=0.007). The overall correlation between MVC with rapid and slow onset was 0.76 at baseline and 0.80 at follow-up, with approximately 5% higher force achieved after slow onset. In the control group the abduction strength of both left and right arm was decreased, but not significantly. Strength in body flexion and extension decreased significantly. The same pattern was seen in the training group with one major exception. Body extension strength increased instead of decreased.
CONCLUSION: The pilots in the training group were instructed and asked to carry out a undulating periodized training program with individual progression and had access to help from educated trainers, but only few managed to train more than 2/3 of the program and 5 did not train at all when left to train alone. The program consisted of 5 different exercises. Shrugs were part of all sessions whereas backward flies and use of bodyblade only was trained in every second pass. This might explain why shoulder strength variables showed the strongest results. At follow-up the pilots felt more confident with the RFD test, which to some extend can explain the progress in both groups. The decrease in some of the tests might be due to time of year changes in activity, as the baseline test was performed in April and the following test in November. Compared to a randomly selected Danish working population (n=423), shoulder MVC was15% higher in the pilot population. It has been questioned, if pilots' are so generally fit that improvements are hard to show, but on this background that should not be the case.

CAFFEINE IMPROVES NEUROMUSCULAR FUNCTION DURING MAXIMAL DYNAMIC CONTRACTIONS

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AIM: The purpose of the present investigation was to determine whether caffeine would affect: 1) muscle contractile properties assessed by voluntary and electrically evoked contractions, 2) force-velocity relationship and 3) mean muscle fiber conduction velocity (CV).
METHODS: Fourteen male subjects [23.8 ± 2.8 (SD) yr] volunteered in a double-blind, repeated-measure study with either placebo (PLA) or caffeine (CAFF) (6 mg kg^{-1}). Maximal twitch and maximal voluntary isometric contractions (MVC) before and after fatigue, maximal isokinetic contractions at different speeds (force-velocity curve) and isometric fatiguing contraction were assessed in the elbow flexors. Mechanical and electromyographic (EMG) signals were recorded and analyzed. CV was estimated from EMG and used as a parameter of interest.
RESULTS: After supplementation, there was an attenuated decline of maximal twitch peak torque (PT) which was 16.8 % higher when subjects assumed CAFF with respect to PLA (P<0.05). Torque-angular velocity curve was enhanced after Cr supplementation and this finding was supported by a concomitant increase of CV values which were on average 8.7 % higher in CAFF at all angular velocities after supplementation (P<0.05).
CONCLUSION: The present study shows that caffeine improves muscle performance during short duration maximal dynamic contractions of the elbow flexors. The concomitant improvement of mean fibers conduction velocity is in support of the hypothesis of an effect of caffeine on muscle recruitment. Also peripheral factors are involved as revealed by findings on electrically induced muscle twitches.

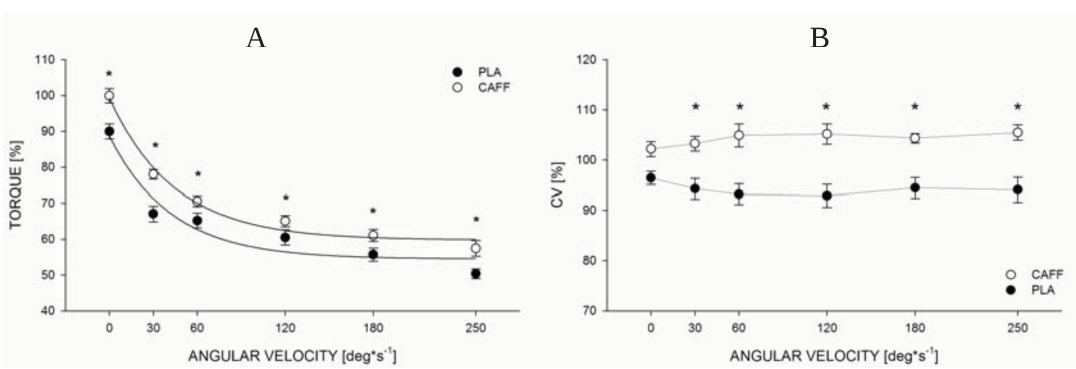

Figure 1: A) Torque-velocity curves in CAFF (open circles) and PLA (closed circles) groups during POST supplementation session. Data are expressed as percentage of MVC values recorded during PRE trial. **B)** CV values in CAFF and PLA during POST supplementation. Data are expressed as percentage of values recorded during PRE trial.
Mean ± SE. *p<0.05 PLA vs CAFF.

BALANCE IS AFFECTED IN OLDER PEOPLE WHO REPORT FALLS

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AIM: Balance disturbance has been linked to retrospective falls risk, but few studies have identified balance parameters related to prospectively reported falls. Such data is necessary to validate measures as potential predictors of future risk. The aim was to determine whether ankle vibration affects standing balance differently in a group of older people who reported 1 or more falls in 5 months, and in a group of older people who did not report any falls.
METHODS: Participants (n=37, 10 female, mean(std); 78(5) years, 77(16) kg, 170(8) cm) stood on a force plate (Fs: 2 kHz, low pass filtered at 12.5 Hz) blindfolded, with headphones with white noise (to prevent distraction) for ~150s. Mechanical vibration (60Hz, 15s.) of both ankles was applied twice to perturb balance; after 15 s. and 75 s. Centre of pressure (cop) data were analyzed in sagittal (AP) and frontal (ML) planes and were divided into 9 x15 sec epochs. For each epoch mean displacement (normalized to first epoch) and standard deviation (SD) were calculated. Dimensionality (Dim) of cop data was calculated (to determine complexity) from the 45s. after the vibrations. Falls data was reported monthly for 5 months, 20 people fell once or more (“fallers”), 17 did not fall (“non-fallers”). To determine differences: repeated measures ANOVA with LSD post hoc test.
RESULTS: The falls group cop displaced more backward during, and more forward after the first vibration (epoch x group; $P<0.001$). Second vibration did not affect cop of the groups differently. However, the falls group cop displaced more forward again after the second vibration. The falls group was more variable in sagittal (epoch x group; $P<0.001$) and frontal (epoch x group; $P=0.02$) plane during and after the first vibration, but increased variability was limited to the sagittal plane during and after the second vibration. A lower Dim was found of the 45s. after both vibrations in the falls group ($P=0.03$). Dim increased during the 45s. after the second vibration in both groups ($P=0.006$).
CONCLUSION: These data provide 2 novel observations. First, the data show that ankle vibration leads to a greater postural disturbance in people who go on to fall in the subsequent 5 months. Second, this is only apparent for the first repetition, suggesting that they have the ability to adapt to the disturbance with practice. There are two possible explanations for the greater disturbance with vibration. Either the fallers have less robust control of balance and have less ideal recovery, or the fallers are more sensitive to vibration. The former alternative is supported by (1) greater displacement in the frontal and sagittal planes, not just the plane of the vibration; (2) more anterior placement of the COP after vibration as this is a safer position; and (3) reduced complexity of the COP after vibration. These data provide novel evidence of balance disturbance that is prospectively related to falls risk and provides a candidate factor for prediction of those at risk.

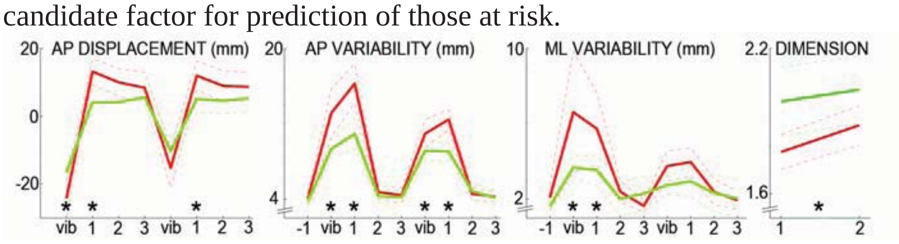

Figure 1: red: fallers, green: non fallers, AP: anterior-posterior, ML: medial lateral, *=sign

PHASE-DEPENDENT MODULATION OF SPINAL REFLEX DURING WALKING IN PATIENTS WITH CHRONIC COMPLETE SPINAL CORD INJURY

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AIM: In healthy subjects, spinal reflexes (SR) evoked by non-noxious tibial nerve stimulation consist of an early (60-120ms latency) component in the ipsilateral tibialis anterior. In chronic (>1 year) complete spinal cord injured (cSCI) subjects early components are small or lacking and replaced by late (120-450ms latency) SR components. In healthy subjects SR are known to be strongly modulated in a phase-dependent manner during walking. The aim of this study was to investigate whether SR are also modulated in subjects with a chronic cSCI.
METHODS: In 10 chronic cSCI subjects SR were evoked during assisted walking in the driven gait orthosis Lokomat (Hocoma AG, Switzerland) with 70% body weight support (BWS). SR responses were randomly evoked during 10 different phases of the gait cycle and electromyographic signals of lower limb muscles of both legs were recorded. SR responses in ipsilateral tibialis anterior during walking were compared to SR responses obtained during a static upright position with 100 % BWS.
RESULTS: In the static condition the late SR component was consistently present in 9 out of 10 subjects while an early SR component could only be seen in 3 subjects. However during walking 9 subjects showed an early SR component while the amplitude of the late SR component became significantly smaller in amplitude. During walking the early SR component was facilitated during the stance-to-swing transition phase while the late SR component was facilitated during late stance phase (Figure 1).
CONCLUSION: This study shows that early SR components are not completely lost in chronic cSCI subjects. Movement-related afferent feedback can re-activate the early SR component and modulate the SR in chronic cSCI subjects.
ACKNOWLEDGEMENT: This work was supported by the European Commission by the seventh framework programme through the ‘Spinal Cord Repair’(HEALTH-F2-2007-201 144) and the Swiss National Science Foundation (NF32-117768/7).

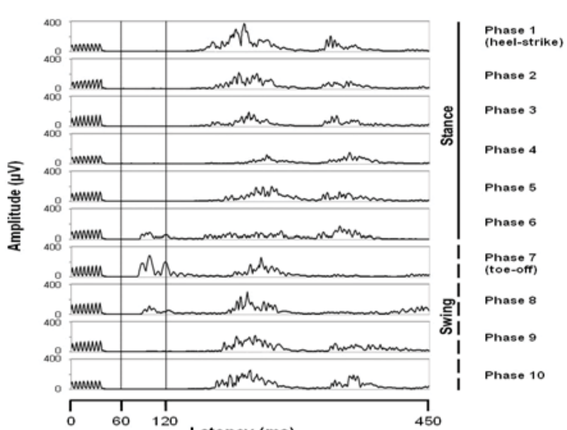

Figure 1: Averaged SR response of one chronic cSCI subject in 10 different phases of the gait cycle.

EFFECTS OF DIFFERENCES IN OBSERVATION CONDITIONS ON MOTOR SKILL LEARNING

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AIM: Observational learning has been demonstrated to be effective in the teaching of motor skills. The issue of what are optimal observation conditions for motor skills learning has, however, not been clarified. The purpose of the present study was to examine the effects of differences in observation conditions on motor skill learning among the uninitiated.
METHODS: Eighteen healthy subjects (12 men and 6 women, mean age: 20.5) participated in this study. The subjects were randomly assigned to the Rive Observation (RO) group, the Video Observation–another (VO–a) group and the Video Observation–own (VO–o) group. The motor task was to throw darts using the non-dominant hand at the center of a circular target. The said target was set up at a distance of 240 cm, and measured 170 cm in height. The diameter of the target was 45 cm. Each subject in the RO group threw darts alternately with another person; each thrower observed the other person when it was not his/her turn to throw. Subjects in the VO–a group threw darts and observed video images of another person doing the same on a PC monitor. Subjects in the VO–o group threw darts and observed video images of themselves throwing darts on the PC monitor. All subjects performed 50 acquisition trials (10 throws×5 sets), retention trials (10 throws 24h later after acquisition trials), and transfer trials (10 throws). In the transfer trial, the target was set at a distance of 290 cm. The distances from the center of the target to the thrown darts (errors in throw) were measured. Further, the Root Mean Square (RMS) of the three-dimensional acceleration change on the forearm was measured using a tri-axial accelerometer to determine the smoothness of motion of the non-dominant hand while throwing darts. The averages of the errors in throw and the RMS were compiled every 10 throws (a block) for the 3 trials; these were analyzed using the repeated two-way analysis of variance (block×group) and repeated one-way analysis of variance (within each group).
RESULTS: The main effect of block and group was a significant reduction in the margin of error, but there was on interactions with each group. There were no significant differences on the margin of error through the all trials in the RO and VO-a groups ($p>0.05$). In the VO-o group, however, there was a significant reduction in the margin of error over the last block as compared to the first block of the 50 acquisition trials ($p<0.01$). And for the VO-o group, there was no significant difference on the margin of error between the acquisition trials and retention trials but there was a significant increase in the transfer trials compared to the last block of the acquisition trials. The RMS was not found to change significantly through the acquisition, retention, and transfer trials in the RO and VO-a groups. In VO-o group, however, the RMS was tend to reduction in the last block as compared to the first 10 throws of the 50 acquisition trials.
CONCLUSION: These results suggested that although differences in observational conditions have a limited impact on the efficacy of repeated learning of a new motor skill, observing oneself simultaneously while learning to pick up a new motor skill is a very effective way. It is thought that observing oneself may facilitate new motor skill learning by integrating the learner’s perception of motion and visual feedback via video.

ELECTROHYSTEROGRAPHIC VOLUME CONDUCTOR MODEL VALIDATION BY HIGH-DENSITY ELECTRODES

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AIM: Electrohysterography (EHG) is the noninvasive measurement of the electrical activity initiating contraction of the uterine smooth muscle (the myometrium) during pregnancy and delivery. Previous studies demonstrated the potential of EHG signal analysis for pregnancy monitoring and timely detection of complications like preterm labor. Unfortunately, several aspects related to the EHG signal are still not fully understood. In order to improve the current estimation accuracy of EHG parameters with clinical relevance (e.g. the EHG conduction velocity), we introduce and validate a model of the EHG volume conductor.
METHODS: The volume conductor is formalized in the spatial-frequency domain by a 4-layer model that adds to existing EMG model, an anisotropic layer representing the abdominal muscle. The physical and geometrical properties of the layers, which correspond to the biological tissues interposed between the myometrium and the recording site on the skin, are the parameters of a transfer function that models the volume conductor effect on EHG biopotentials. Among the parameters of the volume conductor model, the tissue thicknesses can be measured for validation by echography. The intracellular action potential (AP) at the myometrium is analytically modeled in the spatial domain by a Gamma variate function. The EHG signal is recorded by an electrode matrix on five women with contractions. A high spatial resolution of the EHG measurements and a planar approximation of the tissue layers result from the use of electrodes with a small surface and interelectrode distance. In fact, the EHG signal is recorded, for the first time, by a 64-channel high-density electrode grid (TMS international, Enschede, NL). For each patient, the model parameters are estimated, from two segments of the recorded EHG signal, by a least mean square method. For validation, the estimated tissue thicknesses are compared to the average value of two echographic measures.
RESULTS: The mean correlation coefficient (*R*) and standard deviation between the echographic and the EHG estimates were 0.94 and 1.9 mm respectively. No bias was present. In Fig. 1, the average estimated values of fat and abdominal muscle tissue thickness are plotted against the average values measured by echography for the five patients.
CONCLUSION: The proposed mathematical model is in agreement with physiology and can provide an accurate representation of the EHG AP and volume conductor.

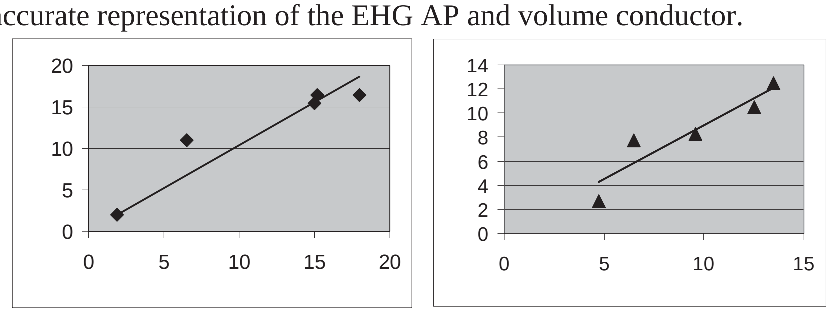

Figure 1: Average estimates of fat (a) and abdominal muscle thickness (b) and trend-line against the corresponding average thickness values measured by echography.

SFIT BASED PLATFORMS FOR REHABILITATION

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The analysis of human movement is generally performed by measuring kinematic variables of anatomic segments with accelerometers, electrogoniometers, electromagnetic sensors or cameras. Conventional sensors often require the application of complex and uncomfortable mechanical plug in order to embed the sensors in the garments, or their use is confined in a defined space; therefore the possibility of having a well fitting sensing garment provides strong advantages in terms of effectiveness and motivation and moreover the possibility to be used for ambulatory assistance in a naturalistic setting.
Smart Fabric and Interactive Textile (SFIT) systems can offer a truly alternative solution, as they enable design and production of wearable non-obtrusive well fitting garments with distributed sensors and electrodes. Systems based on SFIT platform are able to detect fine movements in a natural environment, allowing the monitoring of motion with minimal discomfort for the subject; moreover textile electrodes allow EMG measurements as well as FES therapy, for these reasons SFIT systems are suitable candidate for rehabilitation purpose. Sensing clothes or part of it, like gloves or knee bands can be used for ambulatory therapy addressing different movement disorders.
Sensors can be printed on an elastic fabric without interfering with the final mechanical characteristics of the system, or knitted with seamless technology. This preserves the comfort and sensors functionality of the system.
A platform for Neurological Rehabilitation developed in the frame of an European co-funded project named MyHeart will be described, the system has been developed to support patients in the performance of speech and motor therapy, both when they are still hospitalised, and after discharge, at home.
The SFIT platform has been developed for motor therapy. When sitting at the patient station, patients can review an instructional movie about the exercise they are asked to perform. They are then asked with the help of caregiver, to wear a special sensorized garment and plug it into a portable electronics. After a calibration phase, the motion recognition software starts; it provides a real time feedback on the progress and accuracy of exercises by means of the clear visualisation of simplified symbols such as coloured bars and a smiling or frowning face. The movements have to be repeated until the assigned tool is performed correctly, or a timeout expires. NR system is able to acquire information about the movement of the joints of the upper limb through 29 textile sensors spread on a shirt.
Furthermore, a brief description of the sensing sleeve designed in the frame of TREMOR project will be given, the sleeve has been designed to allow FES therapy and EMG acquisition for patient affected by tremor.
These examples prove that it is possible to combine fabric electrodes and biomechanical textile sensors to conceive systems where gesture recognition function can be combined with EMG detection and FES capability. These platforms can be easily used at home for daily therapy, as well as for telemedicine services.

BRAIN NEURAL COMPUTER INTERFACE FOR TREMOR IDENTIFICATION, CHARACTERIZATION AND TRACKING

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AIM: Tremor constitutes the most common movement disorder; in fact 14.5% of population between 50 to 89 years old suffers from it. Moreover, 65% of patients with upper limb tremor report disability when performing their activities of daily living (ADL). Unfortunately, 25% of patients do not respond to drugs or neurosurgery. In this regard, TREMOR project proposes functional compensation of upper limb tremors with a "soft" wearable robot that applies biomechanical loads by functional electrical stimulation (FES) of muscles. This wearable robot is driven by a Brain Neural Computer Interface (BNCI).
METHODS: TREMOR BNCI (Fig. 1A) assesses generation, transmission and execution of both volitional and tremorous movements based on electroencephalography (EEG), electro-myography (EMG) and inertial sensors (IMUs). The signals are combined to obtain: 1) the intention to perform a voluntary movement from cortical activity (EEG), 2) tremor onset, and an estimation of tremor frequency from muscle activation (EMG), 3) instantaneous tremor amplitude and frequency from kinematic measurements (IMUs). Integration of this information will provide control signals to drive the FES–based "soft" wearable robot.
RESULTS: BNCI is capable of predicting user's intention to move based on corticomuscular coherence in beta band (Fig. 1B) or event related desynchronization (ERD) (Fig. 1C). A Second Order Moment Function (SOMF) is fitted to the tremor bursts recorded with EMG. Inertial sensors provide an accurate estimation of tremor amplitude and frequency (Fig. 1D) based on a two–stage filter constituted by a critically dampened filter and a weighted frequency Fourier linear combiner.
CONCLUSION: Integration of different sources of information provides a fully characteriza–tion of upper limb movements affected by tremor. This information constitutes a robust cognitive human–robot interaction to drive a wearable robot to suppress tremor, and will serve as a tool for neurophysiologic research on the underlying mechanisms of tremors.
ACKNOWLEDGEMENT: We acknowledge the Commission of UE, which funded this research through grant ICT-2007-224051.

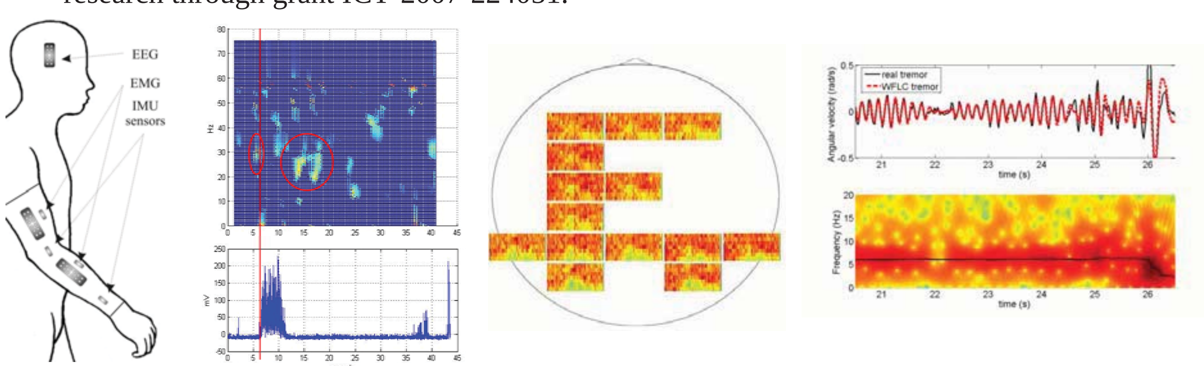

Figure 1: A) Brain Neural Computer Interface for tremor assessment and suppression, B) Detection of movement onset using corticomuscular coherence and C) using ERD, and D) estimation of tremor amplitude and frequency with inertial sensors.

RADIALLY MEASURED TWITCH CONTRACTION TIME CORRELATES WITH FIBRE TYPE COMPOSITION IN HUMAN VASTUS LATERALIS MUSCLE

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AIM: In human physiology muscle twitch contraction time is defined as the time until the twitch forces reaches its peak. It was suggested that damping and elasticity of connective tissues, as well as joint mechanics are major factors influencing force transmission from contractile elements towards the force sensor. But mechanomyographic methods, like Tensiomyography calculate contraction time from radial twitch mechanical response, measured as a displacement/thickening/vibration of the muscle belly. The aim of our study was to correlate muscle composition to radial twitch contraction time in vastus lateralis.
METHODS: Biopsies and tensiomyographic measurements were performed in 21 healthy males and 6 females (average age 42.9 ± 17.9 years). Biopsy tissue was processed to assess myosin heavy chain iso-enzyme composition, while contraction time was calculated from reached 10 % to 90 % of maximal twitch displacement amplitude. We obtained ethical approval of the study as well as written consent was obtained from participants.
RESULTS: The results indicate significant correlation ($R = 0.85$; $P < 0.001$, Figure 1) between the percentage of slow twitch fiber type and radial contraction time, implying that muscle with more slow- twitch fibers have longer contraction time.
CONCLUSION: Results of this study confirms that radial response measured by Tensiomyography carries more intrinsic muscle belly properties than force mechanical response.
ACKNOWLEDGEMENT: We are thankful to all our participants from bed rest Valdoltra studies and European veteran athletic championships 2008.

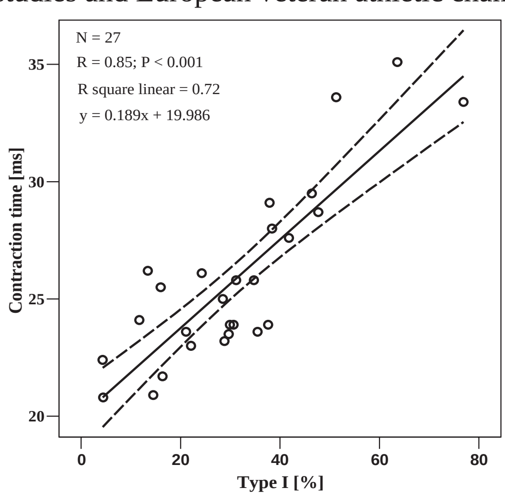

Figure 1: Correlation between contraction time and the percentage of type 1 muscle composition in vastus lateralis.

POSTURAL STABILITY IN CHRONIC LOW BACK PAIN PATIENTS: RELIABILITY OF SWAY MEASUREMENTS

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AIM: Studies have shown reduced postural stability in patients with chronic low back pain (CLBP) compared to a healthy population. Reduced postural stability seems to play a role as a prognostic factor in CLBP patients, and training to improve balance and postural stability is gaining ground in the treatment of CLBP. The clinical relevance of postural stability measured in laboratory facilities is somewhat lacking, as special equipment is required and data is to be filtered before interpretation. The reliability of unfiltered sway measurements in low back pain patients is unclear. The aim of this study is to examine the reliability of sway measurements as a measure of postural stability in patients with CLBP.
METHODS: Postural stability by means of sway measurements were performed using a four channels portable balance platform (HurLabs BT4 www.hurlabs.com). Patients were instructed to stand as quiet as possible in the centre of the platform and eyes focus at a point 3 metre ahead. Every trial lasted 60 seconds; signals were sampled at 200 Hz. The following measures of postural stability were examined: *Trace length:* The trajectory of the centre of pressure (COP); *C90 area*: area of the smallest ellipse containing 90 percent of the COP points; and *Velocity*: Average velocity of the COP. Absolute reliability was assed using the standard error of measurement (SEM) and the minimal detectable change (MDC). Relative reliability was assessed using intra class correlation coefficient (ICC) model 2.1. The number of patients where the difference between test and retest exceeded 15% of the two tests was calculated. Correlations were calculated using Spearman's rho.
RESULTS: 49 patients were included in the study. Results are shown in table 1.
CONCLUSION: the reliability of measures of unfiltered sway measurements with eyes open are poor to acceptable, average velocity of the COP represents the best reliability. Regarding velocity, measures of absolute reliability indicates measurement noise of 1.13 mm/seconds and that a difference greater than 3.13 mm/seconds is likely to be a real difference with 95% certainty. Measures of relative reliability was acceptable (ICC 0.85), but in 22% the differences between the two tests exceeded 15%.

Table 1: Reliability of unfiltered sway measurements, test with eyes open.

n=49	Mean	Mean difference	SEM (95%CI)	MDC	ICC	r	Diff>15%
Trace length 1 Trace length 2	725.47 740.25	-0.92	68 (57; 85)	188	0.84	0.84	11 (22%)
C90 Area 1 C90 Area 2	264.54 265.07	-0.54	87.80 (73; 110)	243	0.53	0.53	33 (67%)
Velocity 1 Velocity 2	12.32 12.34	-0.02	1.13 (0.94; 1.41)	3.13	0.85	0.84	11 (22%)

SEM = standard error of measurement; MDC = minimal detectable change; ICC = intra class correlation coefficient model 2.1; r = Spearman's correlation; Diff>15%= number of patients where difference between the two tests is higher than 15% of mean of the two tests; Trace Length = COP trajectory in mm; C90 Area = area in mm^2 of the smallest ellipse containing 90 percent of the COP points; Velocity = Average velocity in mm/s of the COP.

CHANGES IN REACH PERFORMANCE AND MUSCLE ACTIVATION AFTER SUPPORTED ARM TRAINING IN CHRONIC STROKE PATIENTS

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AIM: After stroke, involuntary coupling of shoulder abduction and elbow flexion can be reduced instantaneously by application of arm support, increasing range of motion. Along these lines, application of arm support as training intervention improves unsupported reach. However, it is largely unknown whether this is related to reduced involuntary coupling or whether other mechanisms are involved. The aim of this pilot study is to obtain insight into underlying mechanisms of changes in reach performance after supported arm training.
METHODS: During 6 weeks, 8 chronic stroke patients received 18 sessions of 30 minutes supported reach training in combination with a rehabilitation game. Unsupported reach was assessed before and after training, involving maximal reach distance, joint angles and muscle activity levels of 8 shoulder and elbow muscles. Pre-post differences were calculated for all outcome measures and evaluated using 90% confidence intervals.
RESULTS: After supported arm training, maximal reach distance improved in all, but 1, patients (mean +3.6% of arm length), together with increased elbow extension (mean +9.2°) and shoulder elevation (mean +4.6°). These improvements were accompanied by increased levels of muscle activity of mainly agonist muscles by at least +20% with respect to pre-training levels. See figure 1 for illustration by a typical example.
CONCLUSIONS: The present findings indicate that improved unsupported reach distance after supported arm training in chronic stroke patients with mild to severe hemiparesis mainly involved an increased activation of prime movers at the shoulder and elbow, but not a reduced involuntary coupling between the shoulder and elbow.
ACKNOWLEDGEMENT: We would like to thank GJ Renzenbrink, MD, and J de Boer, PT, of Rehabilitation Centre ‘Het Roessingh’ for their valuable contributions with patient inclusion and clinical training.

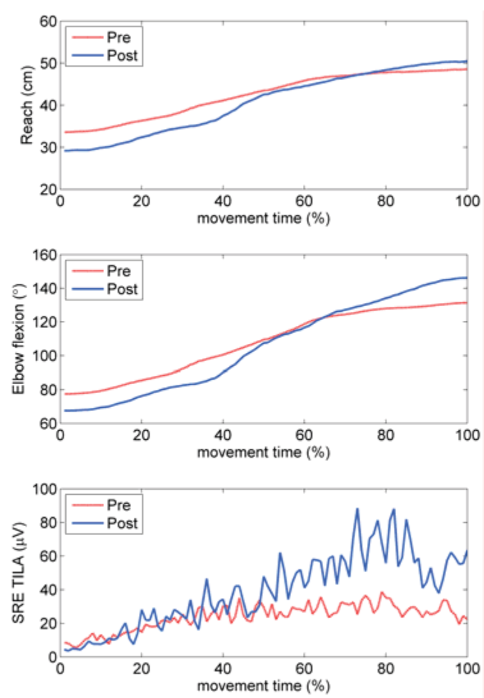

Figure 1: Typical example of data

DEVELOPMENT OF SIMULTANEOUS MEASUREMENT SYSTEM OF MOTOR UNIT DISCHARGE RATE AND CONDUCTION VELOCITY WITH MULTI-CHANNEL SURFACE EMG ELECTRODES

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AIM: The aim of this study is to develop the measurement system with matrix arranged surface EMG electrodes which motor unit discharge rate and muscle fiber conduction velocity (MFCV) can be measured simultaneously and noninvasively.

METHOD: Our developed surface EMG electrode module forms matrix arranged 64 silver wires (sectional diameter 1mm) connected with buffer amplifiers on the epoxy resin board and can record 56 channel bipolar EMG signals. The inter-distances between the neighboring electrodes are parallel 5.0mm (symbolized as d) and then are vertical 2.5mm to the muscle fiber running direction. The gain and the effective frequency band of every amplifier are 74dB and 21-452Hz severally. Then, their recording condition with A/D board is sampling frequency 10kHz and its resolution 12bit. When the subjects exerted right arm 10%MVC isometric flexion on the horizontal plane at elbow angle 90 degree to 180 degree where the elbow completely extended, the EMG signals of biceps brachii muscles were recorded. From the recorded EMG signals, MU action potential trains were classified with EMG signal decomposition technique. Before EMG signal decomposition, independent component analysis (ICA) was applied to the EMG signals to lighten the troublesome jobs of classification. For estimation of MFCV, the time delays τ between neighboring channels to the muscle fiber running direction were calculated with cross-correlation equation. Therefore, MFCV can be calculated with the following equation: $MFCV=d/\tau$. For estimation of MFCV, MU action potential waveforms on the parallel channels to muscle fiber running direction by triggering at their identified MU discharge times. On cross-correlation method, the time delay τ was estimated and then MFCV was estimated from their preprocessed EMG signals.

RESULTS: A measured MU discharge rate was 15.2+/-0.8 times/s and the number of discharge is also 76 times. Our technique can measure individual MFCVs of each MU action potential. The estimated MFCV was ranging from 3.85-4.55m/s and the mean MFCV was 4.37m/s. For estimation of the time delay τ, any correlation values of any MU action potentials showed more than 0.9.

CONCLUSION: Our results show that our developed system can measure MU discharge rate and MFCV simultaneously and noninvasively from the multi-channel surface EMG signals. It is useful for the measurement of the relation between muscle fiber group and central nervous system in single MU. It is indicated that evaluation on more localized muscle fatigue level can be estimated.

REDUCED FLOOR REACTION FORCE DURING STAIR ASCENDING IN PATIENTS WITH KNEE OSTEOARTHRITIS

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AIM: It is well known that knee osteoarthritis (OA) have adverse effects on physical activities or activities of daily living, such as walking, squatting, stair climbing and various type of sitting. Particularly, stair climbing is a more difficult task than other activities for patients with knee OA. The purpose of this study was to determine the characteristics of stair climbing on a floor reaction force in patients with knee OA.
METHODS: Eight patients (1 male and 7 female, 8 knees) with radiographically diagnosed knee OA were participated in this study. Inclusion criteria were as follows; persons who can perform the stair ascending trial without support, no neurological disease and no recent surgical history on lower extremities. This study was approved by the ethics committee of Surugadai Nihon University hospital, and all subjects provided written informed consent. Participant's mean age, height and body weight were 68.8 ± 11.5 years, 152.8 ± 7.4 cm, 58.8 ± 3.7 kg, respectively. Japan Orthopaedic Association (JOA) score for OA (0 - 100 point) was recorded. For measuring floor reaction force, 2 boxes were placed on 2 force plates (Kistler inc.). After calibration, the floor reaction force was recorded during patients ascended the box at their self-selected speed. Force data were imported to the spreadsheet software (Excel 2007, Microsoft inc.), and the peak reaction force of each component (vertical, posterior and lateral) were calculated. Paired t-tests (two-tailed) were used to compare the affected and non-affected leg, and statistical significance level was set at 0.05 probability.
RESULTS: JOA score was significantly lower in the affected leg than in the non-affected leg (71.9 ± 14.1 vs 95.0 ± 7.1, $p<0.01$). The floor reaction force was shown in Table 1. In the affected leg, the vertical force was significantly reduced than in the non-affected leg. No significant differences were found of the posterior and lateral force.
CONCLUSION: Reduced vertical reaction force was found in the affected side of patients with knee OA during stair ascending. This is characterized as one of movement patterns of stair climbing in patients with knee OA. This loss of function of the affected leg may be compensated for by kicking up the ground by non-affected leg.

Table 1: Floor reaction force on stair ascending

Side	**Non-affected leg**	**Affected leg**
Vertical force	598.2 ± 48.3 N	563.1 ± 40.9 N *
Posterior force	70.7 ± 21.0 N	57.1 ± 16.3 N
Lateral force	39.0 ± 14.7 N	42.5 ± 6.2 N

*$p<0.05$

NEUROMECHANICAL CHARACTERIZATION OF TWO DIFFERENT TECHNIQUES OF ROCK CLIMBING

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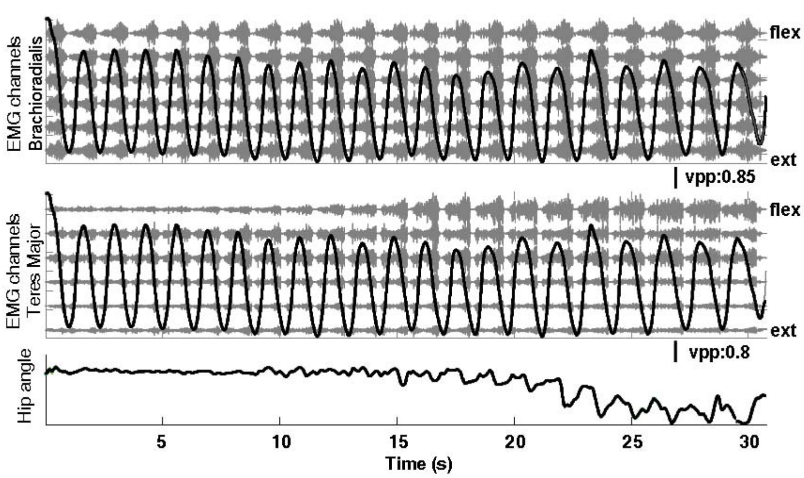
AIM: The aim of this study was to highlight neuromuscular strategies during two different climbing techniques.
METHODS: Ten males medium-high level rock climbers performed five maximal speed chins up (5RM) and, after five minutes of rest, unlimited repetitions of chins up until exhaustion (ERP). sEMG signals were recorded in dynamic condition from the Brachioradialis and Teres Major muscles and two electrogoniometers were fixed at the hip (to assess hip compensation) and to the elbow (to trigger sEMG signal for eccentric/concentric phases). Initial values and normalized rate of change of sEMG variables (average rectified values ARV, mean spectral frequency MNF, and muscle fiber conduction velocity CV) were calculated for the two phases.
RESULTS: In both muscles ARV initial values correlate ($r=0.75$, $p<0.05$) with chin cycle duration initial value (i.e. the faster the chin the higher the signal amplitude). In 8 out of 10 subjects fatigue induces hip compensation (see the Figure). In both muscles and techniques initial values of all EMG variables were found greater (Wilcoxon paired test, $p<0.05$) in concentric than in eccentric phase. In ERP technique and for the Brachioradialis muscle only, CV normalized slopes were found greater ($p<0.01$) for the eccentric than the concentric phase, whereas MNF did the opposite ($p=0.05$).
CONCLUSIONS: This work confirms the possibility to properly record and analyze sEMG signals in dynamic condition. Findings about concentric/eccentric phases confirm that they generate two different strategies, as confirmed by the greater initial values of EMG variables. The mismatch between CV and MNF time courses in the two phases needs further investigation to highlight MU pattern of recruitment.
ACKNOWLEDGEMENTS: The work was carried out with the collaboration of the Sport Climbing Society, CUS Torino, Italy. It is was part of a PhD program funded by Fondazione ISEF, and Compagnia di S. Paolo, Turin, Italy.



sEMG signals from Brachioradialis and Teres Major muscles recorded during endurance test are depicted and the elbow angle trace superimposed.
The hip angle is depicted in the bottom diagram. As fatigue increases, sEMG amplitude and hip compensation movements increase.

OPTIMAL SETUP FOR QUANTIFICATION OF NOCICEPTIVE WITHDRAWAL REFLEX RECEPTIVE FIELDS IN HUMANS

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AIM: The reflex receptive field (RRF) can be defined as the skin area from which a reflex in a specific muscle can be elicited. A method for quantification of nociceptive withdrawal RRFs in humans based on a topographical mapping of the RRF sensitivity has recently been developed however involving a variety of non-optimised parameters. The aim of this study is to identify optimal parameters for assessment of RRFs in humans.
METHODS: Fifteen subjects participated in two sessions, separated by at least 48 hrs. Electrical stimulation was delivered in random order through sixteen surface electrodes non-uniformly distributed on the sole of the foot, applying two different stimulation paradigms: fixed and adjusted stimulation intensities (FSI and ASI), based on subjective pain ratings recorded with a visual analogue scale. Each stimulus consisted of two consecutive trains (3 Hz) of five individual 1 ms constant-current pulses delivered at 200 Hz (felt as two stimuli). Each electrode site was stimulated fifteen times. The response was recorded over the tibialis anterior muscle using surface electromyography (EMG). RRF sensitivity maps were derived by spatial interpolation of the root-mean-square (RMS) amplitude of the reflex responses in the 60-180 ms post-stimulation interval, whereas RRF probability maps were derived by spatial interpolation of the percentage of stimulations eliciting reflexes at each stimulation site. RRF sensitivity areas were calculated as the fraction of the sensitivity map with RMS amplitudes higher than a threshold set by the peak RMS amplitude minus two times the standard deviation of the RMS amplitudes, and RRF probability areas were calculated as the fraction of the probability map with probabilities of occurrence of a reflex higher than 60%. A RRF area estimation error was calculated as the absolute difference between estimations using fifteen repetitions of stimulation and estimations using progressively one to fourteen repetitions. Repeated measures analysis of variance (RM ANOVA) was used to test for differences in stimulation intensities, pain ratings and RRF areas. Intra-class correlation coefficient (ICC) was used to assess the within-session reliability of the RRF area estimations.
RESULTS: The FSI paradigm kept the stimulation intensities constant resulting in a significant drop in the pain ratings after ten repetitions ($p<0.01$). In contrast, the ASI paradigm maintained the pain ratings stable, but significantly increased the stimulation intensities after five and ten repetitions ($p<0.001$). However, the choice of stimulation paradigm did not significantly alter the RRF area. Nevertheless, it did influence the RRF area estimation error: The ASI paradigm entailed larger errors than the FSI paradigm ($p<0.01$). In all cases, the RRF area estimation error remained under 10% after five repetitions, and under 5% after ten repetitions. The 2^{nd} stimulus in the train consistently rendered both larger and more reliable RRF areas than the 1^{st} stimulus especially using the FSI paradigm, with average ICC values of 0.92 for RRF sensitivity area and 0.97 for RRF probability area.
CONCLUSION: RRF sensitivity and probability areas proved to be robust measures against habituation to electrical stimulation and against small variations in stimulation intensities due to different stimulation paradigms, which was not the case for the subjective pain ratings. They also showed relatively low estimation error and high within-session reliability, especially when the 2^{nd} stimulus in the train was used for RRF quantification.

EFFECTS OF 2 WEEKS OF REPEATED ACHILLES TENDON VIBRATION ON TRICEPS SURAE ACTIVATION CAPACITIES

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AIM: Whole-body vibration is now well known for its health benefits. However, such tool cannot be used easily by all patients, especially hypo-active ones. Thus we propose in this study to apply vibration directly to the Achilles tendon and to analyze the effects of such a training program on triceps surae (TS) activation capacities.
METHODS: The 20 subjects were tested before and after a 2-weeks Achilles tendon vibration program (1 hour daily, vibration frequency: 50 Hz). Maximal voluntary isometric torque was determined in plantar-flexion and then sub-maximal contractions were performed at three different torque levels (25, 50 and 75% of maximal voluntary torque). During contractions, twitch interpolation was used to determine an activation deficit by comparing torque production before and with supramaximal electrical stimulation of the tibial posterior nerve. Activation deficit was defined in maximal conditions (AD_{max}) as well as submaximal ones. The slope of the logarithmic relationship between activation deficit and the torque produced gave an index of the deficit in TS activation under submaximal conditions (index of activation deficit) (Figure 1).
RESULTS: After the vibration protocol, the activation deficit in maximal conditions is decreased as well as the activation deficit index under submaximal conditions.
CONCLUSION: TS activation capacities are enhanced after 14 days of daily Achilles tendon vibration. The vibration program involved highly muscle spindles and thus leaded to central adaptations with increase in triceps surae activation capacities. We hypothesize that this can be the result of a more efficient use of the positive proprioceptive feedback loop during voluntary contractions. However, the precise mechanisms responsible for this muscle activation enhancement remain to be elucidated.

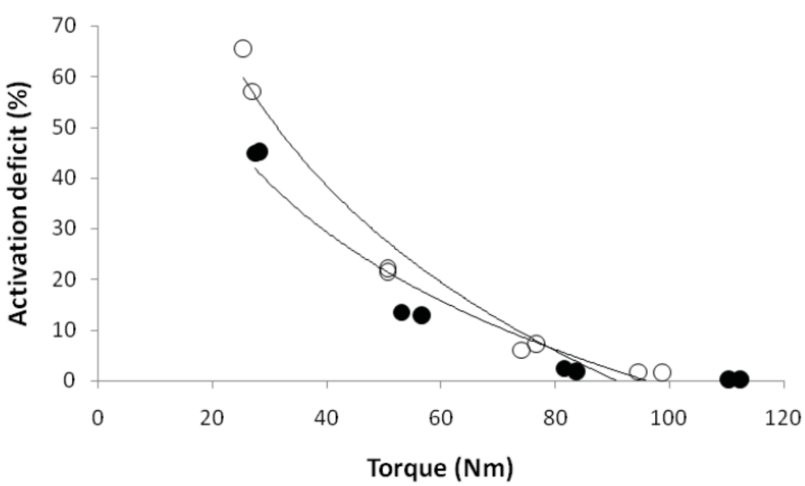

Figure 1: Activation deficit – Torque relationships before (○) and after (●) vibration program.

A MODEL FOR THE RECONSTRUCTION OF LEG JOINT TRAJECTORIES DURING WALKING BASED ON FOURIER SERIES

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AIM: In several fields of rehabilitation engineering, a model aimed at estimating joint trajectories during cyclic movements is widely required. For instance, robots for gait rehabilitation or powered prosthesis for trans-tibial amputee need suitable cyclic trajectories fitting correctly leg joint kinematics during natural locomotion at different walking speeds. Although many authors have used these models, the methodologies to develop them are poorly described in literature (Schmidt et al, ICRA 2004) and there are not data available. A velocity based model for the reconstruction of leg joint trajectories during walking is presented. The model has been developed for young and elderly subjects.
METHODS: Nine young and eight elderly subjects were involved in the measurement session. Subjects were asked to walk on a treadmill at five different speeds from 0.5 to 1.3 m/s. Trajectories of twenty markers placed according with Davis protocol were acquired by using a five camera ELITE$_{PLUS}$ System (BTS, Milano, Italy) with a sample frequency of 100 Hz. Data were pre processed (zero-lag filtering with cut of at 10 Hz) and expressed in a reference frame relative to the pelvis. For each subject leg joint trajectories in the sagittal plane of many steps (minimum 15) were decomposed by using Fourier series in which the period was the averaged duration of the gait cycles; ten harmonics were estimated to account for the greater amount of signal information in accordance with literature (Winter 2005). For each group, linear regression models of amplitude and phase of all harmonics related to hip, knee, and ankle angular excursions versus speed were calculated. The significance of the linear model and root mean square of the difference between reconstructed and measured joint trajectories within a gait cycle was estimated.
RESULTS: The characteristics of the harmonics at different speeds were adequately fitted by linear models, in the range of speed considered ($p<0.05$). For each joint the estimated trajectories were well correlated with those measured on the subjects ($r>0.95$, rms<1°). Therefore, hip, knee and ankle trajectories obtained from the model were comparable with those obtained in natural walking for both young and elderly subjects.
CONCLUSION: The proposed methodology can be applied to estimate joint trajectories of cyclic and quite steady movements. Concerning this study, reported data are suitable to estimate leg joint trajectories of young and elderly subjects.

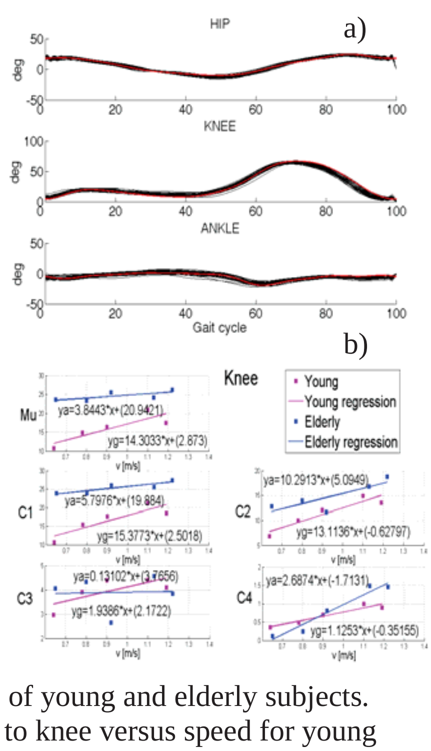

Figure: Linear regression models of five features related to knee versus speed for young (magenta) and elderly (blue) subjects (a). Joint trajectories of a young subject walking at 1.14 m/s (b): curves in red refer to the right and left leg, and black curve represent the Fourier base estimations.

ANALYSYS OF HEART RATE IN THE EXERCISE OF DEEP TRUNK MUSCLES

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AIM: The aim of this study was analyzing heart rate response in the exercise of deep trunk muscles using the balance board and the balance ball. Only a few studies have analyzed during exercise of deep trunk muscles but they were mainly focused on the effects of muscle function.

METHODS: Subjects were six healthy adult males with informed consent. We investigated their heart rate response during two kinds of deep trunk muscle exercise. One of exercises was alternately moving their arm and other side lower limb up and down to each 20 sec in sitting using the balance board (250 mm in diameter, 70 mm in height, Pair Support Co.) (Task 1). Another exercise was using the balance ball (600 mm in diameter, HYGENYC Co.) (Task 2). We analyzed metabolic equivalent (METs), heart rate, low and high frequency component of heart rate (LF and HF) and the ratio of both frequency component (LF/HF) obtained from the fast Fourier transformation (FFT). The statistical analysis was done using SPSS ver16 ($p<0.05$).

RESULTS: Mean value (SD) of METs of task 1 and task 2 was 2.1(0.24) and 2.3(0.20) METs, respectively. Mean value of exercising heart rate of task 1 and task 2 were 86.2(11.8) and 88.3(15.1) beats/min, respectively, and mean value of resting heart rate was 70.9(7.9). There was no significant difference between the heart rate of both tasks, though there was a significant difference between the resting heart rate and the heart rate of tasks. Mean value of HF of task 1 and task 2 was 688.8(417.2) and 561.1(506.1) ms2, respectively. The LF/HF ratio was 1.2(0.91) and 1.1(0.48), respectively. There was no significant difference between the LF/HF ratio values of both tasks.

CONCLUSION: Exercise intensity of two tasks in this study was in the same range. This result showed that trunk muscle activities were in the same range to keep stability of sitting on instability bearing surface and to keep elevating arm and lower limb. HF was showing parasympathetic nervous system activity, and LF/HF ratio was showing sympathetic nervous system activity. There was no difference between these values of both tasks. These results of FFT were suggested that the reaction of the autonomic nervous system was also similar between both tasks.

STROKE INVOLVES DIFFERENT REORGANIZATION OF MUSCLE SYNERGIES BETWEEN LEGS DURING WALKING

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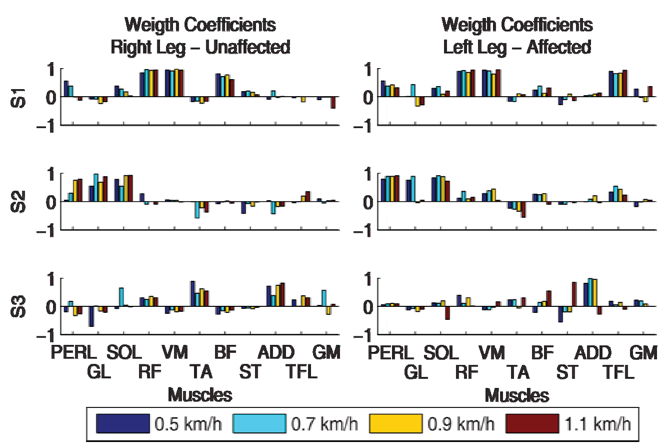
AIM: Reorganization of motor primitives undergoing muscle activation during walking after a stroke has been shown to mainly consist in the reduction of the complex coordination patterns (Clarck and coll., J Neurophysiol 2009). This study is aimed at highlighting whether the differences between affected and unaffected legs in hemiparetic patients reflect functional reorganization of the motor task between the legs.

METHODS: Five healthy and five hemiparetic subjects were asked to walk on a treadmill at 4 controlled speeds (0.5, 0.7, 0.9 and 1.1 km/h) while EMG signals of 11 ipsilateral leg muscles (Peroneus Longus, PERL, Gastrocnemius Lateralis, GL, Soleus, SOL, Rectus Femoris, RF, Vastus Medialis, VM, Tibialis Anterior, TA , Biceps Femoris, BF, Semitendinosus, ST, Adductor Longus, ADD, Tensor Fascia Latae, TFL, Gluteus medius, Gmed) were recorded from both legs. Data were pre-processed (full wave rectification, zero lag low pass filtering with cut off at 10 Hz, average across gait cycles) and 5 muscle synergies have been extracted via Factor Analysis in accordance with Ivanenko and coll. (J Physiol 2004). Comparisons between legs and across walking speeds have been carried out.

RESULTS: The cumulative variance of the 5 synergies was between 85 and 98% did not differ significantly due to the walking speed. Three of the five synergies were systematically reported in all subjects at all walking speeds. These did not show discrepancies across the walking speeds and differed between the legs only in impaired subjects. In particular, during the loading response the unaffected leg appeared leaded by the concomitant activation of knee extensors and biarticular hip extensors (see S1 in Fig) whereas the activity of the TFL of the affected leg intensively controlled the drop of the pelvis. During the propulsive phase, calf muscles appeared to work synergistically even thought the contribution of the GL was absent in the affected leg at faster speeds (see S2 in Fig.). Finally, flexor scheme during the early swing accounted for hip adduction and ankle dorsiflexion only in the unaffected leg, whereas the control of the distal joint aimed at increasing foot clearance was absent in the controlateral leg (see S3 in Fig.).

CONCLUSION: After a stroke, the reorganization of muscle activity during walking accounted for a less complex coordination patterns in accordance with previous literature (Clarck and coll., J Neurophysiol 2009). Moreover, the asymmetrical sharing of the work load between the two legs consists of increasing the contribution of the unaffected leg when propelling forward the body and affecting the intra leg coordination control of the controlateral leg during the swing phase.



Representative set of muscles loading the three main synergies in both the affected and the unaffected leg of a left hemiparetic stroke

THE USE OF EMG IN THE VALIDATION OF MUSCULOSKELETAL MODELS

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Computer models of the musculoskeletal system have many potential applications within sports science, for instance improvement of performance, design of training programs or enhanced knowledge about injury mechanisms. A very important prerequisite is to have justified confidence that the model is an adequate representation of the system it simulates. In other words, these models have to be validated. Validation is the process of determining how well the model represents the real world. Musculoskeletal model validation is complicated by the fact that many variables cannot be measured in real experiments. Common interesting output variables are for example joint reaction forces, which are very difficult or impossible to measure. This leaves the researcher with no other option than using other indirect validation methods. EMG measurements are often used for both direct and indirect validation of musculoskeletal models. However, there are challenges connected with the comparison between EMG and model output.

In this workshop a general introduction will be given about how musculoskeletal models can be validated. Special focus will be given on the use of EMG in the validation of musculoskeletal models. This will be accompanied with validation examples of models created in the AnyBody Modeling System.

Figure 1: A cutting movement simulated in the AnyBody Modeling System.

RELIABILITY OF EMG MEASUREMENTS FOR PLANTAR MUSCLES

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AIM: The foot region plays an important role in postural control. We focused on the foot muscle activity of plantar region. Surface electromyography (EMG) is a non-invasive technique that allows objective evaluation of muscle activity. However, it is difficult to measure the activities of plantar muscles using a standard electrode of surface EMG. We can't evaluate subjects at standing position because of thick electrodes. Therefore, we developed a new thin surface electrode (thickness 0.6 mm, length 16.0 mm, width 17.0 mm) in collaboration with Unique Medical Co., Japan (Fig, 1). The purpose of this study was to investigate the reliability of the plantar muscle activity by means of the new electrodes.
METHODS: Ten (six men and four women) healthy subjects (mean ± SD , age 20.4 ± 1.0 years, height 168.0 ± 9.2 cm, weight 60.0 ± 8.5 kg) participated in this study. Informed consent was obtained from each subject prior to participation. The task of this study was to maintain quiet standing. They were instructed upright standing posture on the floor with comfortable resting foot position and with their arms hanging at their sides. EMG was recorded for 10 seconds during the standing position. Each subject had 2 trials. EMG data were collected with LEG-1000 system (NIHON KODEN, Japan). The surface electrodes were placed on the plantar region of the foot. EMG data were sampled at 1000 Hz . Intra-class correlation coefficients (ICC) were used to estimate the reliability between first trial and second trial.
RESULTS: The ICC value between first trial and second trial was 0.93 (range 0.74-0.98). The reliability of EMG data between first trial and second trial was showed excellent.
CONCLUSION: This study demonstrated excellent reliability. There is no study that the reliability of plantar muscle activities was examined. The findings of this study are important of laboratory research settings for clinical practice. We are searching for the inter-session testing error introduced by variable factors such as skin impedance, subcutaneous tissue depth and electrode position. We must be clearly this variability. Besides, the use of a testing unit with quantitative feedback may overcome this problem. The results of this study showed the reliability of the new electrode. We should improve and test of the new electrode.

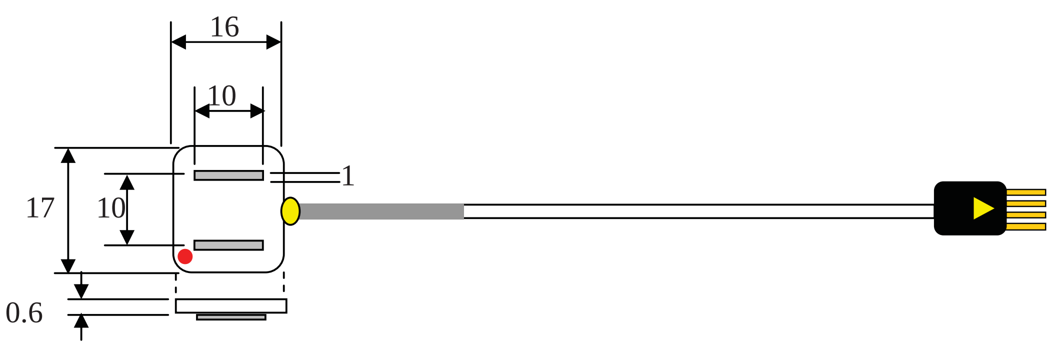

Figure 1: The new thin surface electrode.

EFFECT OF RECOVERY STRATEGIES ON FATIGUE TIME COURSE DURING A SINGLE RESISTANCE TRAINING SESSION ON KNEE EXTENSOR MUSCLES

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AIM: This study investigated the effects of four different recovery modalities on fatigue time course during a single resistance training session on knee extensor muscles.
METHODS: Twelve healthy male volunteers were recruited for this study. Subjects were tested on four separate occasions with the same training session (six sets of 10 maximal concentric knee extensions at 120 $°.s^{-1}$ separated by a 3-min rest). In every session, we applied one of the four recovery modes immediately after each set: passive recovery, active recovery (cycling), electromyostimulation, stretching. Torque was measured during concentric maximal voluntary contractions and evoked electrically in isometric conditions using doublets before, during and at the end of the training session. The associated electromyographic activity of the whole quadriceps was concomitantly recorded.
RESULTS: Maximal voluntary contractions (fig. 1A) and doublets (fig. 1B) were altered during and at the end of the training session. Quadriceps electromyographic activity and activation level only decreased at the end of the training session.
CONCLUSION: Fatigue appeared progressively during the training session with peripheral alterations occurring first followed by central ones. Different recovery interventions between sets did not modify fatigue time course.

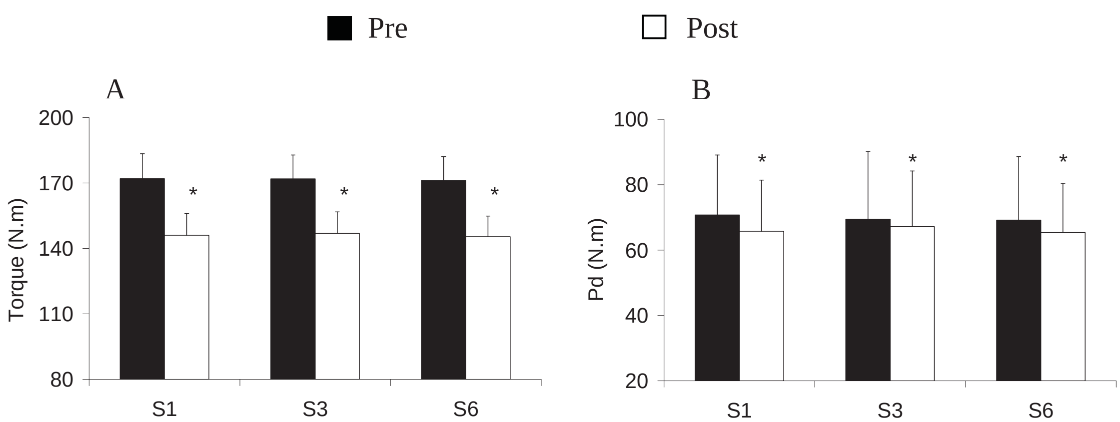

Figure 1: Mean maximal voluntary torque (A) and peak doublet (Pd; B) developed just before and after sets 1, 3 and 6. Since there were no differences between recovery modes, values are the average of the four recovery modalities. Significant differences between pre and post for a given set (* $p < 0.05$).

EFFECTS OF CUTANEOUS INPUT BY MEANS OF HIGHLY ELASTIC ADHESIVE TAPE ON MOTOR NEURON POOL EXCITABILITY

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AIM: We reported previously that motor imagery executed with cutaneous input by cutaneous input tape (CIT) facilitated corticospinal tract excitability. However, the amount of influence induced by the cutaneous input has not been clarified. The purpose of the present study was to clarify the influence of the CIT on the gain modification of the spinal reflex.
METHODS: Healthy subjects participated in this experiment. There were four test conditions, the rest condition: Rest, the cutaneous input-rest condition: CI-Rest, the motor imagery condition: MI, and the cutaneous input-motor imagery condition: CI-MI. H-reflex was recorded from the right soleus muscle for each condition. CIT was applied from the right sole to the gastrocnemius muscle. The motor imagery was executed, so that the ankle plantar flexion was imaged in the brain. H-reflex test stimulus intensity was defined as the level at which half amplitude of the maximum H-reflex amplitude could be evoked.
RESULTS: The mean value of H-reflex amplitude increased in the order of Rest, MI, CI-Rest, and CI-MI, and there was a significant main effect on the condition. A post hoc test revealed that the H-reflex amplitude increased more significantly in CI-MI than in Rest or MI. The increasing ratio of H-reflex amplitude during motor imagery was significantly larger than that recorded without CIT (Figure 1).
CONCLUSION: The results of this study suggested that CIT affects the motor neuron pool excitability at the spinal level during motor imagery. One possible explanation is that two independent facilitatory effects of CIT and the motor imagery were finally detected after those independent interventions were combined. Another possible explanation is purposive utilization. A facilitatory effect of gain modification induced by taping was shown during motor imagery, but this effect did not occur during the rest condition, when no motor imagery was invoked.

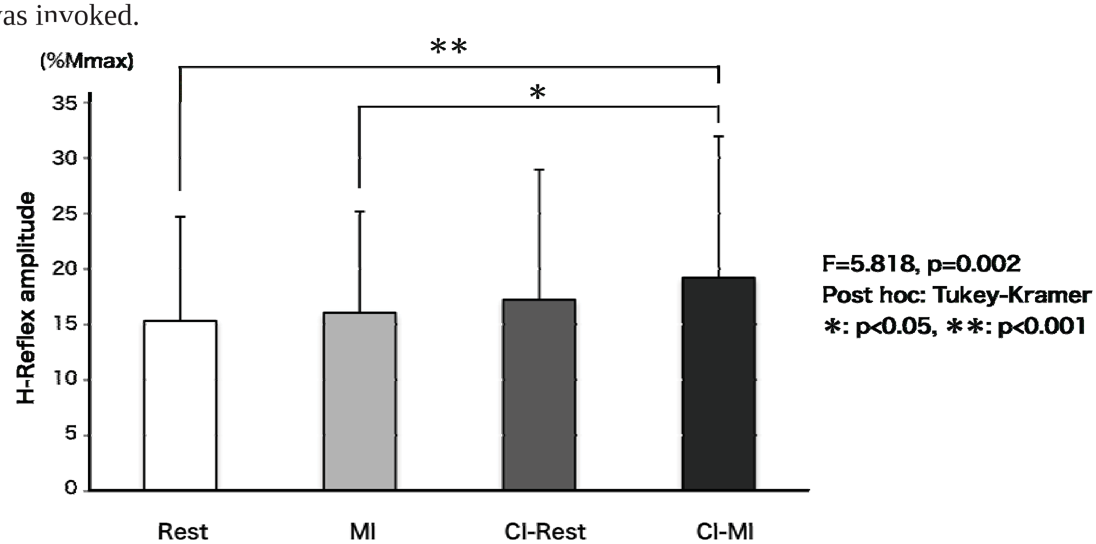

Figure 1: The mean value of H-reflex amplitude.

ELECTRICAL STIMULATION FOR ENHANCING RECOVERY IN SPORT

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Fatigue, defined as any exercise-induced impairment in muscular contractility, is generally considered to originate from two main mechanisms (Enoka and Stuart, 1992). Central fatigue arises proximal to the motor axons and leads to reductions of motor unit activation. Peripheral fatigue is located within the muscle itself, with components also related to the neuromuscular junction or terminal branches of the motor axons. Both mechanisms have been shown to be related to metabolic changes in active muscles such as hydrogen ion, inorganic phosphate accumulations.
Nowadays, elite sport requires high-volume and high-intensity training. Training as well as competition repetition (more particularly in team sport) inevitably induced a neuromuscular fatigue that would appear detrimental for performance enhancements. Therefore, improving recovery processes is fundamental. It will allow athletes to compete and train altogether with potentially reduced fatigue, muscle soreness or even injury risks. A wide variety of recovery modalities could be proposed (Barnett, 2006). Among them, active recovery, alternating contraction and rest periods, creates a "pumping effect" that will favor blood flow and therefore metabolites clearance. These active recovery modalities generally consisted in light solicitation of the neuromuscular system such as pedaling, running or electromyostimulation. This last method is largely adopted particularly in endurance-type and team sport athletes. When used with low frequencies, this type of solicitation induces short and low intensive contractions. It consequently appears adequate for metabolite clearance and therefore to accelerate recovery kinetics during and after fatiguing exercises, training sessions or competition. Although electromyostimulation is often used for recovery, limited evidence exists regarding an improvement of most physiological variables or reduced subjective rating of muscle soreness. Therefore, practical aspects of electromyostimulation as well as recent results from the literature will be exposed in the presentation to clarify the usefulness of this modality for recovery.

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Enoka RM, Stuart DG. Neurobiology of muscle fatigue. J Appl Physiol 72: 1631-1648, 1992.

ELECTRICAL STIMULATION OF THE PERIPHERAL NERVOUS SYSTEM: SOME UNRESOLVED ISSUES

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The aim of this contribution is to examine some limitations in our understanding of the physiological mechanisms underlying the neural and muscular responses to electrical stimulation (ES) and to present a number of problems which limit the comparisons among the results obtained in different laboratories (such as the large varieties of methodological approaches used for muscle stimulation and of testing procedures aimed to describe and quantify the neural and muscular responses). With such an approach, we aim to provide a conceptual foundation for subsequent studies in this area.

In exercise and sport, ES is used to assess the neuromuscular function in vivo, but more importantly it is used to promote strength-training like adaptations. Skeletal muscles benefit from ES use, despite it is applied in an empirical manner, often based on personal experience or manufacturers claims rather than on scientific evidence.

In general, ES current parameters are poorly reported and there is a considerable heterogeneity between the different studies. This is due to the fact that researchers and clinicians tend to consider the different forms of electrical stimulation as a whole, irrespective of the species (human versus animal), of the stimulation model, of the type, size and location of electrodes, of the stimulus parameters and of the muscle being stimulated. We contend that the key factor for optimizing ES is muscle tension, i.e., the level of evoked force (with respect to maximal voluntary force), which should be maximized - whenever possible - via an appropriate manipulation of the two main ES current parameters: frequency (50-100 Hz) and intensity (as high as possible).

Surface ES activates motor units without any specific sequencing related to unit types (i.e., random or disorderly recruitment), which implies that some fast units can be activated even at relatively low levels of force. Such peculiarity of ES recruitment inevitably entails some disadvantages (e.g., onset and extent of muscle fatigue) but also several advantages, particularly for athletes requiring high levels of muscle strength and power, but also for individuals presenting a selective impairment of fast muscle fibers (elderly subjects).

Despite ES is commonly viewed as a technique to induce muscle contractions with a negligible contribution of the central nervous system, several lines of evidence indicate a considerable involvement of different neural structures during ES. In accordance with this contention, it has even been suggested that ES would provide a multimodal bombardment of the central nervous system, which results in increased cortical activity as well as in spinal motoneuron recruitment. This reflexive recruitment, which activates motor units in the normal physiological recruitment order, could be maximized through simple experimental manipulation of stimulus pulse duration (1 ms) and frequency (>50 Hz). Such physiological phenomenon remains however to be demonstrated for commonly stimulated muscles such as the quadriceps femoris.

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EYE MOVEMENT STRATEGIES FOR SINUSOIDAL FORCE-TRACKING OF DIFFERENT TARGET MOTION STIMULI

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AIM: The current study was conducted to investigate the effects of target motion on tracking maneuver, elaborating on eye movements and their roles in on-line control of hand movements.
METHODS: Fourteen volunteers performed 0.5 Hz sinusoidal force-tracking with two different display modes of target (line and wave modes); meanwhile eye movements and tracking output during the whole tracking session were recorded.
RESULTS: The results showed that the eye movements and tracking errors depended strongly on display mode. Line-mode tracking caused a remarkable higher ratio of eye excursion to target displacement ($R\_{EYE/TARGET}$) than wave-mode tracking. In addition, line-mode tracking also yielded frequent pursuit movements than wave-mode tracking, especially in the initial, mid, and terminal phases of a tracking cycle. In contrast, higher incidence of fixation movement was found in wave-mode tracking than in line-mode tracking. However, presence of saccadic movements did not vary with display mode. Tracking performance fluctuated in a tracking cycle, pertaining functionally to presence of eye movements. Irrespective of display mode, tracking error multiplied with high incidence of saccadic movement of a tracking cycle, but tracking error decline when high incidence of fixational movement presented. Besides, tracking errors of line-mode tracking concurred with high incidence of pursuit movement.
CONCLUSIONS: In conclusion, modes of visual feedback predominated information of spatial updating for the oculomotor system in pursuit of a moving target, resulting in display-dependent organization of eye-hand coupling to accomplish the same tracking goal.

NEUROMUSCULAR REFLEX EVALUATION WITH MULTI-CHANNEL SURFACE EMG SIGNAL DECOMPOSITION TECHNIQUE

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AIM: The purpose of this study is to evaluate activities of motor unit (MU), i.e. mean and variability of inter-pulse interval, for neuromuscular reflex function and is to develop the system to measure the parameters with multi-channel surface EMG signals.
METHODS: The subjects sat the chair and were fastened around both shoulders with the belts. When the subjects flexed their right arms at horizontal plane, the surface EMG signals on biceps brachii muscles were recorded during isometric contraction at their elbow angle 90, 120, 150 degree to 180 degree at which the positions of their elbows completely extended. Assume that constant torque was loading around the elbows, constant contraction force at their biceps brachii muscles were loaded. The subjects can keep constant loads to their biceps brachii muscles by means of visual feedback of their force level to fit the target force level on the front monitor. The surface EMG signals with 7x8 matrix-like silver electrodes and the force signal at the right hand were recorded simultaneously. The sampling frequency was 10kHz and also its resolution was 12bit during the experiments. Every EMG amplifiers' gain was 74dB and its efficient frequency band was ranging from 21Hz to 452Hz. After recording, independent component analysis (ICA) was applied to their EMG signals to easily detect MU action potentials by means of EMG signal decomposition based on waveform classification. From the classification of MU action potential trains, the inter-pulse interval (IPI) and its variability were calculated. On this system, classifying the same MU action potential trains from some channel pairs of EMG signals made the accuracy of their calculation become higher because you can recognize that the discharge times of the same MU between the different channels were nearly equal though the slight time delays between the different channels were occurred.
RESULTS: Our result shows that IPI are proportionally decreased as elbow angle are increased because it is suggested that, as biceps brachii muscle is stretched, the muscle spindle in biceps brachii muscle is also stretched and excites α-motoneuron in spinal cord by positive feedback. Then, the variability (defined as standard deviation) of IPI were also decreased as elbow angle are increased. The fact indicates that the reduction of the variability may be associated with inhibition of α-motoneuron by negative feedback of the neurotendinous spindle and Renshaw cells because it is well known that negative feedback makes a system be stabilized.
CONCLUSION: Our results show that our developed system with multi-channel surface EMG signals may be able to measure not only MU activity but only reflex function of neuromuscular system. The practical measurement of MU activity with EMG signal decomposition showed not only that IPI reflect the active level of MU but also that the variability of MU discharge intervals may be associated with reflex function. Then, it is also expected that this system with the surface EMG electrode module may make MU activities be measured in wider range of body movement and during more loading than ordinary systems with invasive EMG electrode module.
ACKNOWLEDGEMENT: This work was supported by KAKENHI 21700587 (Grant-in-Aid for Young Scientists (B)) of Japan Society for the Promotion of Science and The Ministry of Education, Culture, Sports, Science and Technology.

EFFECTS OF ADD MUSCLES ON ELECTROMYOGRAPHIC ACTIVITY OF THE VASTUS MEDIALIS OBLIQUE AND VASTUS LATERALIS DURING A 45° SEMI SQUAT IN SUBJECTS WITH PATELLOFEMORAL PAIN SYNDROME.

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AIM: The purpose of this study was to determine the activity of the VMO and VL muscle using surface electromyography (EMGs), and establish the existence of an increase in electromyographic activity relationship between the two muscles to perform isometric hip adduction in individuals with patello-femoral pain syndrome (PPS) 45°semi squat.
METHODS: 14 subjects (7 healthy and 7 with PPS) were evaluated with EMGs in VMO and VL muscles during the execution of a 45°semi squat and 45°semi squat with isometric hip adduction. We measured the contribution of the adductor muscle with the RMS normalized records of each subject. For statistical analysis we used the Mann-Whitney U test for two independent populations with a significance level of 0.05.
RESULTS: The results show that there were no statistically significant differences ($p \leq 0.05$) in the relationship of electromyographic activity VMO / VL between healthy subjects and PPS to make a 45°semi squat with isometric hip adduction.
CONCLUSION: This study shows that even when there is an increase of EMGs activity of VMO and VL muscles, to perform isometric hip adduction in 45°semi squat does not produce significant changes in the EMGs relationship VMO / VL in healthy subjects and with patella-femoral pain syndrome. This result is consistent with other studies that show an increased activation of the VMO and VL muscles when isometric hip adduction semi squat is combined with 45° of knee flexion in healthy subjects and subjects with PPS.
Therefore the 45° semi squat associated with hip adduction increases activation of vastus medialis oblique and vastus lateralis in normal subjects and subjects with patello-femoral pain syndrome, which may be beneficial in the rehabilitation process because it shows that the pathology of these patients do not generate significant changes in the pattern of EMGs activity.

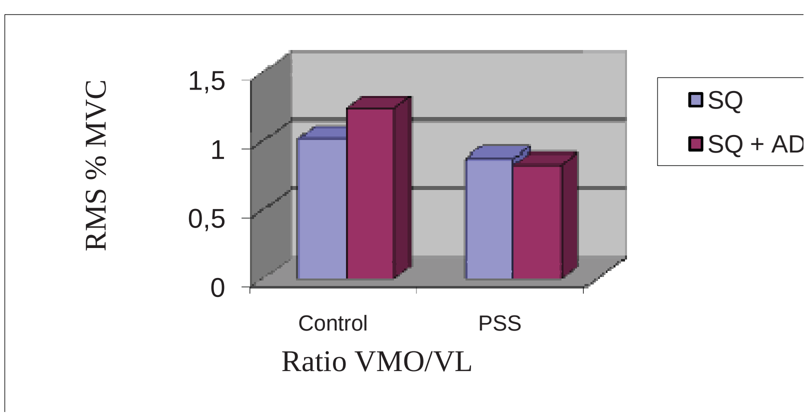

Figure 1: This graph illustrates a relationship between VMO/VL in healthy subjects and with patello-femoral pain syndrome in 45° semi squat (SQ) and 45° semi squat associated with hip adduction (SQ+ADD) situations

IMPACT OF BALANCE TRAINIG WITH A VIRTUAL REALITY IN ELDERLY

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AIM: aim of this study was to proving whether the postural control parameters changed after an intervention with a virtual reality in elderly people.
METHODS: Our study populations included 20 older individuals (mean= 69,5 years). All participants gave written, informed consent to participate in the study. The subjects were training with a intervention model of tree times a week during 8 weeks with 20 minutes per session. Postural balance was measured on a force platform. Two test were applied: 1) bipedal stance, 2) tandem stance, each test had two phases (open eyes and close eyes) and was performed four times, before the intervention at 3, 6 and 8 weeks of the training with a virtual reality game. The statistical significance tests were performed using test t-student paired with a $p < 0.05$.
RESULTS: In bipedal stance there were significant changes in the area and velocity of displacement of the center of pressure (DCoP) in open eyes phase. The follow values were observed in third (X: 0,01026±0,001), sixth (X: 0,00784±0,001) and eighth week (X: 0,0074±0,001) belonging to the area, and in third (0,23476±0.004) and eighth week (0,22665±0.002) for mean velocity ($p < 0.05$). In tandem stance there were significant changes in the area of DCoP in open eyes phase in third (X: 0,03714±0,007), sixth (X: 0,02853±0,004) and eighth week(X: 0,02689±0,004) ($p<0.05$). Mean velocity of DCoP showed significant changes in closed eyes phase in third (X: 0,50136±0,02); sixth (X: 0,46545±0,02) and eighth week(X: 0,45201±0,02) ($p<0.05$).
CONCLUSION: The virtual reality generate a training with sensory feedback at several sensorial levels and it is the reason of the significant decrease in balance parameters like area in open eyes phase in both test and the mean velocity in open eyes phase of bipedal stance test and in closed eyes for tandem stance test. Then this kind of training generate that the older individuals used efficiently their visual and vestibular systems in both bipedal stance and tandem stance performances. Therefore the change in balance parameters is a consequence of improving in use of sensorial systems.

ELECTROMYOGRAPHIC AND CLINICAL EVALUATION OF NECK FLEXOR MUSCLE IN WOMEN WITH MILD CERVICAL DISABILITY

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AIM: The purpose of this study is to investigate the correlations and differences between clinical and biomechanical evaluation of the cervical spine in nondisabled women and women with low cervical disability, in order to help to quantify substantiation of the clinical evaluation the health professional, to obtain an efficient clinical management of patients with neck pain.
METHODS: Trans-sectional descriptive study. A sample of 20 secretaries subdivided into a group with low disability (as disability test cervical Vernon) and a nondisabled control group, were assessed fatigue index (50% CVM) of neck flexor muscles (sternocleidomastoid and scalene) by surface electromyography and was performed kinematics analysis of the cervical range of movement. We utilized the T-Student with significance level of 0.05 to determine mean differences and used Pearson correlation to determine the statistical correlations between clinical variables biomechanical vs. intragroup and intergroup, intragroup and intergroup clinical variables and biomechanical inter-and intra-group.
RESULTS: Clinical variables were found to have a high correlation with each other (0.726) within a group of the biomechanical variables (0.643), however to assess mean differences was evident that the control group showed greater variability among the group biomechanical with low disabilities ($p < 0.005$). Were not found statistically significant differences in fatigue index between groups.
CONCLUSION: By comparing the biomechanical variables with literature, it appears that a relationship there is strong correlations in intragroup and intergroup, but in this study no statistically significant intergroup differences were found, unlike the other investigations there are statistically significant differences. The controversy that exists is in relation to the separate groups in the investigations, since in most research groups divided into control v / s subjects with severe chronic pain, therefore, follows that are more heterogeneous groups, with greater variability. In this study, the study groups are similar and there is more variability. What might deduce that the EMG and kinematic analysis of the cervical spine are more sensitive assessments when the groups are more variable in their pathophysiologic condition and are probably plotting significant difference, or that this population of women whose activities are highly labor applicant for the cervical spine presenting as alterations in the physiological or neural control level in the group that is asymptomatic and that would be given by a pathological adaptation of the cervical musculature to external demands.

MULTI-TIME SCALE EVALUATION OF PROLONGED FATIGUE FOR CUSTOMIZING ELECTRIC TORQUE-ASSISTTED BICYCLES

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AIM: Many variations in physical activity occur uphill road cycling. To achieve effective pedaling performance individually with an electric torque-assisted bicycle (TAB), several time-scales for evaluating physical activity should be studied in terms of prolonged fatigue. METHODS: We recorded ECG with the chest electrode V6 and bipolar surface EMG (SEMG) from the biceps femoris (BF), vastus lateralis (VL), tibialis anterior (TA), and gastrocnemius (GM) muscles using the active two-bar electrodes (DE2.1, Delsys). Both ECG and SEMG were sampled at 2048 Hz with 12-bit resolution using the potable unit composed of a notebook PC and amplifiers. The participants were eight healthy young male volunteers (23.8 ± 2.3 yrs), five middle age female volunteers (44.2 ± 6.3 yrs), and four elderly male volunteers (61.3 ± 8.1 yrs). They were informed of the risks involved and signed a consent form in advance. For the 2100-m long circuit, we divided around 400-m uphill road into three phases with different inclination. An experimental set consisted of four consecutive trials with the three different assist profile types (total 68 trials) and each trial was separated over 20-min for rest. Each participant was asked to keep the pedaling rate as close to 60 rpm as possible. Along with the torque profile we estimated the profiles of the averaged rectified value (ARV) and the mean power frequency (MPF) of SEMG at a pedal stroke, sliding the 100-msec interval every 10-msec for a segment consisted of several tens strokes in the first and third phases. Expressing the profiles as a function of crank angle and elapsed time at four lower-limb muscles, we compared them by the correlation coefficient, . Besides, we ensemble-averaged the integrated EMG at every stroke to obtain iEMG in each phase, and then normalized it by iEMG in the first phases to assess muscle fatigue. RESULTS: Muscle fatigue was assessed by increase in ARV and decrease in MPF for a segment. Figure 1 shows ARV profile presenting progressive fatigue at VL. The profile with crank angle was steady in a non-fatigue trial, while one with elapsed time varied in the third phase. Normalized iEMG significantly increased in fatiguing trials at BF and TA. Such variation related to individual fatigability, regardless of age and gender related groups and electric torque profile of TAB (Table 1). CONCLUSION: For fatigue assessment over uphill road cycling using SEMG related profiles, normalized iEMG, and , we showed that at least three time-scales (stroke, segment, and trial scales) were required to effectively customize an electric torque-assisted bicycle.

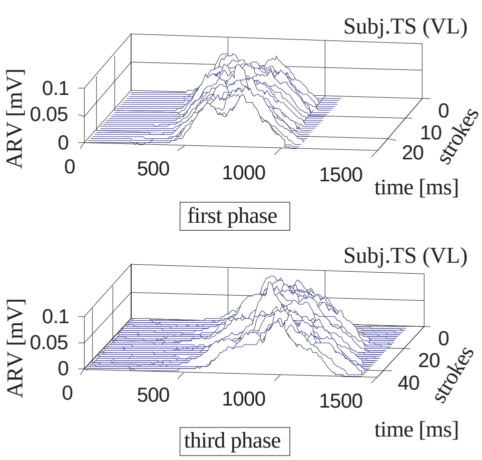

Figure 1: ARV profiles with elapsed time in the first and third phases.

Table 1: Number of trials for each group.

	fatigue (27)	non-fatigue (41)
young males (32)	31% (10)	69% (22)
middle age females (20)	45% (9)	55% (11)
elderly males (16)	50% (8)	50% (8)

DIFFERENTIAL TREMOR DYNAMICS OF CONCURRENT POINTING TASKS ON QUIET STANCE AND SEESAW STANCE

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AIM: Limb segments in upright stance are coordinated specifically to balance constraints. This study was to investigate how degree of instability of a stance surface affected fine coordinative control of postural pointing, in light of stance-related restructuring of multi-segment physiological tremors.

METHODS: Twenty healthy volunteers performed a postural pointing task on two different stance surfaces, level surface (LS) and rocker board (RB). Eight dual-axis accelerometers were attached to limb segments, including the right index finger, hand, forearm, arm, lumbar, thigh, calf, and foot, to record physiological tremors during the postural-suprapostural tasks. Low-frequency movement fluctuations (≦1 Hz) of the stance surface and the pointing index were recorded with an accelerometer and a laser detector. The intensity of physiological tremors and movement fluctuations were represented with values of root mean square (RMS). Regularity of segment tremors and tremor coupling between adjacent segments were quantified with approximate entropy (ApEn) and partial correlation, respectively. A Hotelling T^2 statistics was used to examine the difference in the RMS, ApEn, partial correlation coefficients of segment fluctuations between two stance conditions. A significant level of .05 and paired *t*-test with Bonferroni correction for post-hoc analyses were used.

RESULTS: Compared with LS stance, RB stance resulted in significantly greater RMS of physiological tremors, particularly in the arm and the lower limb ($p < .001$). The tremor partial correlation coefficients varied with supporting surface of stance surface ($p< .001$), with a general enhancement of tremor coupling in the upper limb but a remarked uncoupling in the hand-forearm, arm-lumbar and calf-foot complexes ($p < .001$). RB stance led to a greater regularity in segment tremors of the lower limb ($p < .001$), in support of increase in active control of limb segments for postural steadiness on a round balance plate.

CONCLUSION: Stance-related organization of segment tremors revealed coordinative strategies for postural pointing under various balance challenges. During RB stance, the subjects released positive coupling of the trunk and the ankle joint in accommodation to fluctuation movements of the rocker board, but intensified tremor coupling stiffness of the upper limb as a mean of mastering redundancy in joint space for pointing task.

ASSESSMENT OF MUSCLE ACTIVITIES ON MAGNETIC RESONANCE IMAGING SIGNAL INTENSITIES DURING SUSTAINED TRUNK EXTENSION EXERCISE

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AIM: Muscle activity can be assessed by electromyography (EMG), and only superficial muscles can be assessed using surface EMG. In this study, we have attempted to assess the activity of deep muscles by measuring changes in magnetic resonance imaging (MRI) signal intensities during sustained exercise.
METHODS: The subjects were 4 male adults aged between 19 and 22 years. Each participant provided written informed consent before enrollment. The subjects lay in the prone position in the bore of the MRI scanner at a trunk extension of 15°, with pillows placed under the stomach. The trunk was scanned in this extended position. After MRI scanning, the pillows were removed, and the subjects were asked to remain in their positions for 6 min. MRI was performed 4 times at 1, 2, 4, and 6 min after the initiation of the exercise. The system used was the 1.5-T Magnetom Symphony scanner (SIEMENS Inc.). The images were obtained using the true fast imaging with steady-state precession (FISP) technique (repetition time [TR] = 4.30 ms, echo time [TE] = 2.15 ms, number of excitations [NEX] = 1, flip angle [FA] = 50°, scan time = 10 s, field of view [FOV] = 400 mm). Signal intensities for each muscle were calculated from the MRI data and the results were compared. The muscles analyzed were the musculus multifidus (MF), musculus longissimus lumborum (LL), musculus iliocostalis lumborum (IL), and musculus quadratus lumborum (QL). The 4^{th} lumbar vertebra was scanned in both the horizontal and transverse directions for the analysis. Bilateral MR signals were calculated for each muscle, and the MRI signals at each time point were compared by two-factor repeated measures ANOVA using SPSS ver.15. The 4 muscles and scans taken at each time point were assumed to be within-subject factors. A value of $p < 0.05$ was considered statically significant.
RESULTS: The average signal intensities before and during exercise were showed Table 1. The 4 muscles interaction shows a significant difference (Table 2).
CONCLUSION: While MF, LL, and IL are strong trunk extensor muscles, QL is an assistant mover in trunk extension. Therefore, the change in signal intensities of QL was different from other muscles. These results indicated that changes in MRI signal intensities denote the change in muscle activities with time.

Table 1: Signal intensities

	before exercise	1 min	2 min	4 min	6 min
MF	89.1 (8.5)	87.8 (6.7)	88.5 (6.6)	91.1 (10.2)	97.1 (7.1)
LL	96.9 (14.0)	98.3 (12.1)	97.0 (13.8)	98.0 (13.5)	107.6 (17.2)
IL	87.9 (12.4)	90.5 (12.9)	88.1 (12.3)	88.4 (12.0)	96.6 (14.6)
QL	74.0 (7.9)	73.9 (9.2)	72.9 (10.3)	71.1 (11.7)	75.0 (9.3)

Table 2: Results of two-factor repeated-measures ANOVA

	DF	F value	*p* value
muscle	3	29.57	$p < 0.05$
time after the initiation of exercise	4	5.31	$p < 0.05$
interaction	12	2.86	$p < 0.05$

A LOSS OF IA AFFERENT FEEDBACK MAY CONTRIBUTE TO QUADRICEPS INHIBITION IN PATIENTS WITH KNEE OSTEOARTHRITIS.

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AIM: Knee injury, surgery and arthritis are associated with an inability to fully activate the quadriceps muscle, a process known as arthrogenic muscle inhibition (AMI). A loss of excitatory feedback from primary muscle spindles has been shown to contribute to AMI in patients who have ruptured their anterior cruciate ligament (ACL), a deficit termed gamma-loop dysfunction. However, it remains unknown whether this mechanism contributes to AMI in other types of knee joint pathology. The purpose of this study was to determine whether quadriceps gamma-loop dysfunction is present in subjects with knee osteoarthritis (OA).
METHODS: Fifteen subjects with radiographically confirmed knee OA and fifteen age and gender matched controls with no history of knee joint pathology participated in this study. Quadriceps and hamstrings force and electromyography (EMG) were collected during maximum effort isometric contractions of the quadriceps and hamstring muscles at 90° of knee flexion. Thereafter, 20 minutes of 50Hz vibration was applied to the infrapatellar tendon using an electromechanical tapper. After tendon vibration, maximum effort isometric contractions of the quadriceps and hamstrings were repeated, with force and EMG collected in an identical manner to baseline testing. Quadriceps and hamstrings peak force were converted into torque measurements and normalised as a percentage of body mass for each subject. The root mean square (RMS) of the EMG signals was calculated and used in subsequent analyses. If normal Ia afferent feedback is present, the effect of vibration is to decrease strength and EMG levels, usually by 8-10%. If dysfunctional, then strength and EMG levels will not change following vibration. Thus one sample t-tests were undertaken to analyse whether percent changes in torque and RMS differed from zero after vibration in each group. The alpha level was set at 0.05.
RESULTS: Following tendon vibration, quadriceps peak torque decreased significantly in the control group ($p < 0.05$) but did not change in OA subjects ($p > 0.05$). Hamstrings peak torque was unchanged in both groups ($p > 0.05$). Similarly, after tendon vibration RMS of the quadriceps ($p < 0.01$) decreased in the control group, but was unchanged in the OA group ($p > 0.05$). RMS of the hamstrings remained unchanged in both groups ($p > 0.05$).
CONCLUSION: The results of this study suggest that quadriceps gamma-loop dysfunction is present in patients with OA of the knee joint. Prolonged tendon vibration temporarily reduces transmission in Ia afferent nerve fibres. The subsequent loss of excitatory input from primary muscle spindles prevents full activation of the muscle by descending pathways. Thus, a decrease in quadriceps peak torque and RMS is expected after infrapatellar tendon vibration, and indicates an intact gamma-loop. In contrast, the lack of change in quadriceps activation seen in OA subjects suggests that Ia afferent transmission was already impaired in these patients. Quadriceps gamma-loop dysfunction may occur due to a loss of sensory output from the damaged knee joint. Gamma-loop dysfunction may contribute to quadriceps AMI in patients with OA, partially explaining the marked weakness and atrophy that is often observed in this muscle group.

TMS STUDY ON THE LONG-TERM POTENTIATION-LIKE EFFECT IN THE CORTICOMOTOR AREA AFTER MULTIPLE SYNCHRONIZED STIMULATIONS WITH MOTOR IMAGERY

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AIM: The authors of several studies have reported that transcranial direct current stimulation (tDCS) or transcranial magnetic stimulation (TMS) could change corticomotor excitability, so that the motor performance changed in parallel to the physiological change. The present study was executed to clarify whether there was a long-term potentiation-like effect on the corticomotor area after multiple synchronized stimulations, which we produced for the future clinical use to promote motor relearning, for example, in a stroke patient.
METHODS: Healthy male subjects participated in this experiment. Each subject sat on a comfortable seat, and their left hand was fixed on an experimental table. A figure-of-eight coil was used to induce motor-evoked potentials from the first dorsal interossei (FDI) and abductor digiti minimi (ADM). The stimulation intensities were 105%, 115%, and 125% of the resting threshold. The corticomotor excitability was examined before the intervention and at multiple stages after the intervention (0 min, 15 min, 30 min, 60 min). A multiple synchronized stimulation was applied as an experimental intervention. A pair of rubber electrodes was set on both sides of the motor cortex, and tDCS was applied for 20 minutes. A subject performed motor imagery of FDI abduction during the electrical stimulation, and also visual illusion was prompted by a movie of someone else's index finger abduction (Kaneko F, Neuroscience, 2007). MEP amplitudes were compared among the stages after the normalization by supra-M wave amplitude.
RESULTS: One-way ANOVA indicated there was a significant main effect of the stage on the MEP amplitude. The result of 115% showed marked statistical significance of MEP amplitude at each stage of cortico motor area excitability examined 0 min, 15 min, and 30 min after the intervention. The largest change was shown at stage 15 min, and the relative ratio to that before the intervention was about 150%.
CONCLUSION: To induce changes in excitability in the cortical-motor area, we produced multiple synchronized stimulations as an intervention. The present results revealed that our original intervention in this study could induce a long-term potentiation-like effect on the cortico-motor area for at least 30 minutes. The results of the present intervention may be even longer lasting than those induced by tDCS reported in previous studies.

BEGINNING MOVEMENT LOAD TRAINING IMPROVES STEADINESS OF OLDER ADULTS DURING SUBMAXIMAL ISOMETRIC CONTRACTIONS

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AIM: Beginning Movement Load (BML) training comprises exercises with relatively light loads and muscle contractions that comprise a relaxation-lengthening-shortening sequence of actions. The purpose of the study was to determine the influence of BML training on the steadiness of submaximal isometric contractions performed by older adults.
METHODS: Twenty-four subjects were randomly assigned to either a BML training group (n = 17, 67.5 ± 5.2 yr) or a control group (n = 7, 65.3 ± 7.9 yr). The subjects in the BML training group exercised on 7-types of machines (Dips, Chest spread, Lat pull-down, Outer, Leg press, Inner thigh, Pull over) with a 30%-1RM load and 5-7 sets of 15 repetitions, 2-3 times/wk for 8 wks. The dependent variables were the maximal voluntary contraction (MVC) force and the coefficient of variation (CV) for force during submaximal isometric contractions (10%, 30%, and 65 %MVC) with the right elbow flexors and right knee extensors. The measurements were performed at 0, 4, and 8 wks. The surface EMG was recorded from the biceps brachii, brachioradialis, and triceps brachii at elbow and rectus femoris, vastus medialis, vastus lateralis, and biceps femoris muscles during all tasks. The average rectified EMG signal (aEMG) for each trial was normalized to the MVC values.
RESULTS: The MVC force for the subjects in the training group increased significantly for the knee extensors (27.6 %) but not the elbow flexors (8.0 %). In contrast, the CV for force declined significantly for both muscle groups at all three target forces for the training group but not the control group (Table 1).

Table 1. CV for force (%) at the three target forces before and after 8 wks of training.

	10%		30%		65%	
	Before	After	Before	After	Before	After
Elbow flexors						
BML training	2.98 ± 0.2	2.21 ± 0.2†	2.29 ± 0.2	1.33 ± 0.1†	2.54 ± 0.2	1.74 ± 0.1†
Control	2.79 ± 0.1	3.26 ± 0.2	2.08 ± 0.1	2.09 ± 0.2	2.36 ± 0.2	2.30 ± 0.2
Knee extensors						
BML training	2.77 ± 0.3	1.93 ± 0.2*	2.34 ± 0.2	1.47 ± 0.1†	2.11 ± 0.1	1.53 ± 0.1†
Control	2.52 ± 0.2	2.55 ± 0.1	2.24 ± 0.2	2.04 ± 0.2	1.95 ± 0.1	1.96 ± 0.1

Values indicate means ± SE. *$p < 0.05$ and †$p < 0.01$ vs. Before

Except for an increase in the aEMG for triceps brachii during the 65 % MVC contraction (9.6 ± 3.6 % MVC, P = 0.051), there were no significant changes in aEMG for the 3 target forces.
CONCLUSION: BML training improved steadiness during submaximal isometric contractions performed by older adults with the elbow flexors and knee extensors.
ACKNOWLEDGEMENT: Supported by grants from the Ministry of Education, Culture, Sports, Science and Technology of Japan.

REACHMAN ROBOT FOR TRAINING REACHING AND MANIPULATION IN SUBACUTE STROKE PATIENTS

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AIM: There is a growing body of evidence to suggest that augmenting exercise therapy time early after stroke improves outcome [I]. This seems to be especially the case in the upper limb, where high-intensity and task-specific treatment consisting of active, highly repetitive movements has been seen to be one of the most effective approaches to recovery in arm and hand function [II-IV]. Providing this augmented, high intensity therapy is labor-intensive and has resource issues. Rehabilitation robots promise a solution to this problem, though few studies have examined training of manipulation and training in the sub-acute phase. The study's objective is to evaluate the potential of ReachMAN as a rehabilitation tool for sub-acute stroke patients. ReachMAN is a compact 3 degree-of-freedom robot to train reaching, pronosupination and grasping, all critical to manipulation (Fig. 1).
METHODS: Three sub-acute patients (36, 53 and 61 years old) participated in the study. Inclusion criteria included *i*) single stroke within 3 months prior to the study, *ii*) no major shoulder complications, *iii*) able to understand instructions and *iv*) no visual impairment. Patients carried out ten 30-minutes-long sessions over a period of four weeks. No specific number of trial movements had to be performed in a session, and the patient could stop the session if he became tired or experienced pain. In each session, patients trained in four different exercises namely reaching, pronosupination, grasping and combination of reaching and pronosupination with ReachMAN. The sequence and number of exercises were adapted to the performance of the patient.
RESULTS: No pain or discomfort was reported by the patients during or after training with the robot. Overall, throughout the 10 sessions patients increased the number of trials per session, successful trials, range of movement and strength (Table 1). One patient improved in Fugl-Meyer from 28 to 43. The other two patients were too weak to reflect an improvement in functional assessments, however they increased the successful trials from 57.1% to 80.9% and 37.5% to 92.8%, and significantly increased the movement range and smoothness.
CONCLUSION: The results suggest that ReachMAN can be used to increase upper limb motor activity, range of movements and smoothness in subacute patients. A larger clinical study is now in progress, which is looking at the use of ReachMan in subacute patients, in addition to their normal therapy, compared to a control group.

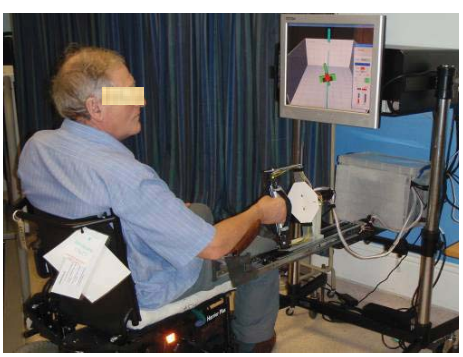

Figure 1. A sub acute patient training with ReachMAN

Table 1:Results at 1st and 10th session with ReachMAN

	P1		**P2**		**P3**	
Force	**1st**	**10th**	**1st**	**10th**	**1st**	**10th**
Pushing (N)	8	25	5	9	12	25
Pulling(N)	20	30	12	10	10	28
Pronation (Nm)	0	0.83	0	0	0	0.13
Supination (Nm)	0	0.51	0	0	0	0.23
Range of Motion						
Reaching (mm)	100	150	30	70	30	40
Pronosupination (°)	0	90	0	0	0	20
Grasping (cm)	0	50	0	0	0	0
Number of trials						
Reaching	50	220	110	110	80	110
Pronosupination	40	70	10	70	20	30
Grasping	20	60	10	20	20	0
Successful trials(%)	90.5	85.9	57.1	80.9	37.5	92.8

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EFFICACY OF ACCELEROMETERS FOR THE EVALUATION OF KNEE LATERAL THRUST

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AIM: Motion analysis is a very important evaluation performed by physical therapists. However, unlike muscular strength and range of motion, motion is difficult to examine objectively. Consequently, motion analysis tends to be subjective and is based on the visual judgment of individual therapists. It is possible to conduct objective motion analysis by using 3D analyzers, force plates, and electrogoniometers. However, these systems are still too expensive, bulky, and time consuming. In contrast, 3-axis accelerometers and gyroscopes are inexpensive and portable. However, a method of motion analysis by using these instruments has not been established. In this study, we prepared elastic tights that performed a taping function (taping tights) in order to limit the lateral thrust of the knee joint and determined whether motion analysis could be effectively performed using an accelerometer and taping tights.

METHODS: Eight healthy young adults who had provided written informed consent beforehand participated in this study. We prepared 4 types of taping tights with different fiber runs and strengths in order to identify an effective taping tight. The participants were asked to perform a drop-landing task from a 30-cm height. Each participant was required to perform 3 successful trials. A successful trial was defined as one in which the subject dropped down on the right leg to the force platform, “stuck” the landing, and did not touch the ground with the opposite limb. The participants were tested under 5 conditions, with (taping tight conditions) and without the taping tights (control condition). The accelerometer was fixed on the lateral aspect of the knee joint, and accelerations all around the knee were measured. Data regarding acceleration and floor-reaction force were compared using one-way analysis of variance; the Tukey method was used for multiple comparisons. The level of statistical significance was defined at 5%.

RESULTS: Lateral acceleration of the knee joint in the taping tight conditions was significantly lower than that in the control condition. Moreover, among the 4 types of tights, the ones in which the fibers ran along the vastus medialis muscle were associated with the lowest lateral acceleration values. The forward acceleration in the taping tight conditions was larger than that in the control condition, but not significantly so. No characteristic differences in the floor-reaction force were noted between the taping tight conditions and the control condition.

CONCLUSION: We confirmed that the lateral thrust of the knee joint upon a drop landing can be evaluated using an accelerometer. In addition, we evaluated the differences among the 4 types of taping tights by using the accelerometer. Therefore, we propose that the accelerometer is a very effective motion-analysis tool.

BLOOD OXYGEN SATURATION DECREASES WITH INCREASING FATIGUE OF TRAPEZIUS AND STERNOCLEIDOMASTOIDIAN MUSCLES

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AIM: This work investigated in normal human subjects the evolution of blood oxygen saturation (SaO_2) with increasing fatigue of Trapezius and Sternocleidomastoidian muscles, while performing sustained contractions.
METHODS: To monitor the fatigue development, the surface electromyogram (SEMG) were recorded simultaneously in left&right Trapezius and Sternocleidomastoidian muscles of the human (n = 20), during sustained contraction at 50 % MVC (Maximal Voluntary Contraction), up to exhaustion. Pairs of electrodes (H59P, MVAP, USA) were placed on each investigated muscle. The subject sitting on a chair, with a 90^o anteflexion between the forearm and the arm, had to push with the external occipital protuberance against a transducer (extension Ex), or to pull (flexion Fl) via a soft belt attached to the forehead. The 100% MVC was estimated, as the maximal force that could be sustained for two seconds. Tests were performed at 50% MVC (monitored with an oscilloscope) up to exhaustion, on different days. The SaO_2 was taken with a probe fixed on the distal falanges of left hand through OXY100C module of the BIOPAC system (BIOPAC SYSTEMS INC, USA). The SEMGs, force signals, SaO2, were acquired at 1000 samples/second. The Instantaneous Median Scale (IMedS) was computed from SEMG via the Continuous Wavelet Transform (30 scales, 'Mexican Hat' mother wavelet) to quantify the development of the fatigue. Linear regression was performed on SaO_2 data. The Intercept ($ISaO_2$) and Slope ($SSaO_2$) were computed.
RESULTS: With developing fatigue IMedS increased, while SaO_2 decreased, in all subjects, either in Ex or Fl. The average SaO_2 at rest was 98.25+-0.68 % (mean +-standard deviation). The overall average of $SSaO_2$ was $-2.25*10^{-3}$+-$3.03*10^{-3}$ %/s, with overall $SSaO_2$ $-2.27*10^{-3}$+-$3.29*10^{-3}$ %/s for females (F) and $-2.19*10^{-3}$ +- $2.02*10^{-3}$ for males (M). The t-test showed no significant differences (p=0.05) between the average $SSaO_2$ in Ex and Fl, yet a significant difference was shown between F and M: (i) $SSaO_2$ is higher in F ($-2.64*10^{-3}$+-$2.57*10^{-3}$ %/s) than in M ($-1.02*10^{-3}$+-$1.11*10^{-3}$ %/s) in Ex and (ii) $SSaO_2$ is higher in M ($-2.77*10^{-3}$+-$2.17*10^{-3}$ %/s) than in F ($-1.93*10^{-3}$+-$3.86*10^{-3}$ %/s) in Fl.
Between the beginning and the volitional end of the contraction (exhaustion) of the exercise, the overall average difference in SaO_2 was -0.704+-0.580 %.
CONCLUSION: Developing fatigue in exhausting steady contraction of 50% MVC is associated with an increase of IMedS and a decrease of SaO_2 (negative $SSaO_2$). The significant difference in $SSaO_2$ (Ex) between F and M may be due to less developed and less trained Trapezius muscles in F. The significant difference in $SSaO_2$ between F and M in Fl (higher $SSaO_2$ in M) may be explained by a more hypoxic exercise due to a tendency of males to use more back and chest muscles, which restricts respiration. Reduced SaO_2 may contribute to diminish the motor drive to the working muscles, thus reducing the endurance and contributing to the early termination of the contraction. Thus, in sustained contraction, $SSaO_2$ acts as an index of fatiguability, which leaves room for further investigation.
ACKNOWLEDGEMENT: This work was performed under research grant 82108/2008-CNMP/Romania.

DOES VISUAL FLOW ALTER LOWER LIMB MUSCLE ACTIVATION DURING DROP LANDIGNS IN PATIENTS WITH FUNCTIONAL ANKLE INSTABILITY?

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AIM: Functional ankle instability (FAI) is defined as impaired proprioception, strength, postural control, and neuromuscular control without ligamentous laxity following acute ankle injury. Previously, it is postulated that delayed reflex responses to stress on ankle ligaments resulted in the damage to ankle joint receptors at the time of initial injury; however, no conclusive results were presented in people with FAI when performing functional activities, for example, landing tasks. We aimed to examine the characteristics of muscle activation in lower limbs during drop landings in subjects with and without FAI. Second, we also examine any difference of motor control strategies of lower limbs in these people during drop landings in four visual conditions.
METHODS: A total of twenty-eight subjects (age range 20 - 32 years, mean 21.7 ±3.2 years, BMI 21.6 ±2.1 SD) were volunteered to recruited, which comprised 8 (4 males, 4 females) people with unilateral FAI and 20 controls (10 males, 10 females) with matched age and BMI. They randomly performed series of landing movements (forward drop landing from 40-cm height) with four visual conditions (no limitation, limitation below level, partial limitation and all limitation). Electromyography data (rectus femoris, biceps femoris, tibialis anteriors, peroneal brevis, peroneal longus and gastrocnemius lateralis) in the lower dominant and injured extremity were collected simultaneously using a forceplate (Kistler Corp, USA) and surface electromyography system (Delsys Inc, USA). The onset time of muscle activation were determined by a custom-made program written by Matlab 7.0 (The Mathworks Inc, USA)
RESULTS: Significant earlier activations of PL, LG and PB before drop landings in all vision conditions were found in subjects with and without FAI. Significant difference of PB and TA muscle activations were found between subjects with and without FAI, which is shown in visual limitation below level (TA $p = 0.038$; PB $p = 0.01$) and partial visual limitation (TA $p = 0.027$).
CONCLUSION: Subjects with FAI tend to change muscle activation patterns in the lower limb to adapt drop landings. In challenging tasks, such as drop landings with partial vision field limitation, subjects with FAI may cause ankle joint damage due to the alterations of motor control strategies.
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EFFECTS OF BALANCE TRAINING WITH VIRTUAL REALITY ON POSTURAL CONTROL IN OLDER AGE GROUP

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AIM: The aim of this study was to demonstrate whether the postural control parameters are changed after an intervention with a virtual reality.
METHODS: 20 older subjects were assess with posturographic platform in bipedal and tandem positions then they were submit to protocol of balance training across eight weeks with a virtual reality game.
RESULTS: There were significant changes in the displacement of the center of pressure (DCoP), especially in the area of DCoP with closed eyes phase and in velocity of DCoP in open eyes phase both in bipedal. These changes in DCoP parameters being the most notorious in tandem.
CONCLUSION: The increased postural stiffness in old age compared to young people is often associated with an abnormal response coordination associated with old age. This increase in rigidity in old age can be attributed to passive changes in osteo-ligaments, joints, or due to an active postural response strategy. So training with sensory feedback at several sensorial levels could be the reason of the greater changes in subjects older than musculoskeletal influence of training.

SINCERITY OF EFFORT VERSUS FEIGNED MOVEMENT CONTROL OF THE CERVICAL SPINE IN ASYMPTOMATIC PEOPLE AND PATIENTS WITH WHIPLASH-ASSOCIATED DISORDERS

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AIM: To ascertain how asymptomatic people and patients with chronic whiplash–associated disorders (WAD) simulate deficits of movement control of the cervical spine and to establish quantitative parameters capable of differentiating maximal (sincere) versus sub-maximal (feigned) levels of effort.
METHODS: Sixty-five men and women participated in the study, thirty-one asymptomatic individuals and thirty-four patients with chronic WAD, grade II. The subjects tracked a moving fly which appeared on a computer screen using a 3D Fastrak device (The Fly method®). Easy–medium–difficult movement patterns were tested on two separate sessions. Amplitude accuracy (deviation of movements in mm), directional accuracy (time on target, undershoots vs. overshoots in %) were compared across patterns and groups on two occasions. During the first test session (Test 1), the participants were asked to use head movements to track the patterns traced by the fly as accurately as possible. They were then presented with a short vignette describing a fictitious accident (the asymptomatic group) or to imagine they were suffering more intense pain (the WAD group) and asked, using the same protocol, to repeat the head tracking as if they had experienced an injury/or higher level of pain. No further instructions were provided. A retest (Test 2) in reverse order (feigned effort first) took place 3 weeks later.
RESULTS: The sincere effort of the WAD group compared to the feigned effort of the asymptomatic group was significantly better in all movement patterns on both test sessions for amplitude accuracy ($P < 0.001$). The discriminant analysis revealed that mean score above 5.5 mm, differentiated feigned performances of the asymptomatic group from the WAD group´s sincere effort (sensitivity 79,4%, specificity 67.7%). The asymptomatic group spent 40% of the test "time on target" in their sincer effort, compared to 25% for the WAD group. In their feigned effort, the asymptomatic group spent significantly less "time on target", than the WAD group in their sincer effort ($P < 0.001$). Score above 11% in the "time on target" outcome indicated correctly categorized WAD patients (sensitivity 82,3%, specificity 64,5%).
CONCLUSION: The results indicate that the Fly method® was capable of differentiating between true WAD sufferers and asymptomatic individuals who feigned their performance. Certain stategies were detected in the feigned performances of the test. The results may be of practical significance for evaluating validity of whiplash claims.

EFFECTS OF HIGH HEELS WALKING ON KINEMATIC AND KINETIC PARAMETERS DURING STAIR ASCENT AND DESCENT.
－COMPARISON OF NON-SKILLED AND SKILLED －

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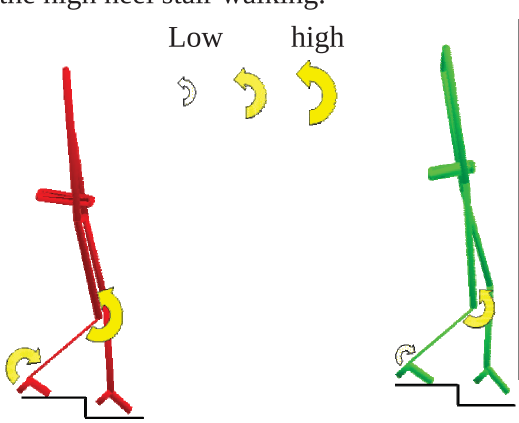
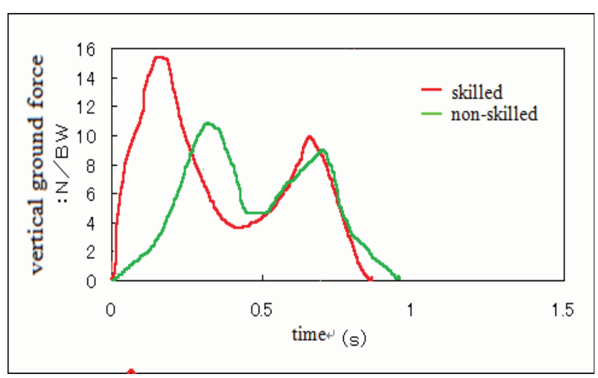
AIM：We examined the effect of high heel shoes on kinematic and kinetic walking parameters in healthy skilled and non-skilled users during stair ascent and descent by using three-dimensional motion analysis and floor reaction force.

METHODS：Six healthy females without a history of orthopedic disease participated in this study(3 skilled high heel shoes users and 3 non-skilled one). A skilled was defined as the one who had worn high heel shoes more than 6 hours a day, and 5 days a week for over 5 years. In order to measure the kinematic walking parameters, a three-dimensional motion analyzer (VICON612) with 8 infrared camera units was used. The floor reaction force was set for the kinetic parameters. Steps used were adopted 30cm tread width and 16cm riser, using in public facilities in Japan. The high heel shoes used was their own. The mean height of the heel was 5.5cm(5～6cm) for skilled, and 3.5cm(3～4cm) for non-skilled, respectively. Data was measure at any speed for each subject.

RESULTS：The walking speeds and cycles in both group was similar during ascent. The extension momentum of the hip was slightly reduced and extension momentum was relatively high in the skilled during ascent. During descent, the locomotion speed of the skilled was relatively faster than that of the non-skilled. However, the plantar flexion momentum of the ankle and extension momentum of the knee at initial stance phase in the skilled showed large value, and significant difference was found between the groups (Figure 1). The vertical ground force components at the initial stance phase was observed relatively higher than that of flat floor walking as expected. (Figure 2)

CONCLUSION： There was a tendency to give priority to the speed rather than the stability in the skilled. The result suggested that the load to the knee and ankle joints was increased in the high heel stair walking.





skilled non-skilled

Figure 1: Knee and ankle joint moments **Figure 2:** The vertical ground force.

PAIN AS UNDERLYING FACTOR OF HANDWRITING DIFFICULTIES IN JUVENILE IDIOPATHIC ARTHRITIS

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AIM: The aim of the current study was to define the handwriting difficulties that occur in elementary school children with Juvenile Idiopathic Arthritis (JIA) and to investigate the underlying impairments to these limitations.
METHODS: Following a cross-sectional approach 15 children with JIA and 15 healthy matched controls were included. Hand function measures, handwriting parameters, perceived handwriting difficulties and pain were assessed.
RESULTS: While overall the children with JIA performed well during short-term handwriting, the number of letters written per minute decreased significantly. Children did report difficulties due to pain during handwriting and limitation in sustaining handwriting throughout the day. Only minor hand impairments were found and these did not correlate with handwriting difficulties. Pain was found to be the major underlying factor of handwriting difficulties in JIA. Pain after handwriting highly correlated with the letters written in 5 minutes (Pearson correlation coefficient (r)= 0.779; p=0.001), i.e. the more they wrote, the more pain they experienced. This effect was not found in the control group (r= 0.202; p=0.471) (Fig. 1). Further the rated pain after handwriting in the JIA group is correlated with age (r=0.543; p=0.036), the older the children the higher the score on the 100 mm visual analogues scale (VAS-pain). No correlation with age was found for VAS-pain rating before handwriting (r= 0.232; p=0.406) and after force measurements (r= -0.323; p=0.240).
CONCLUSION: While short-time performance of handwriting is not impaired in children with JIA, pain during handwriting and limitation of sustaining handwriting throughout the day are the major handwriting difficulties in children with JIA. The pain the child experiences during handwriting is an indication for difficulties.

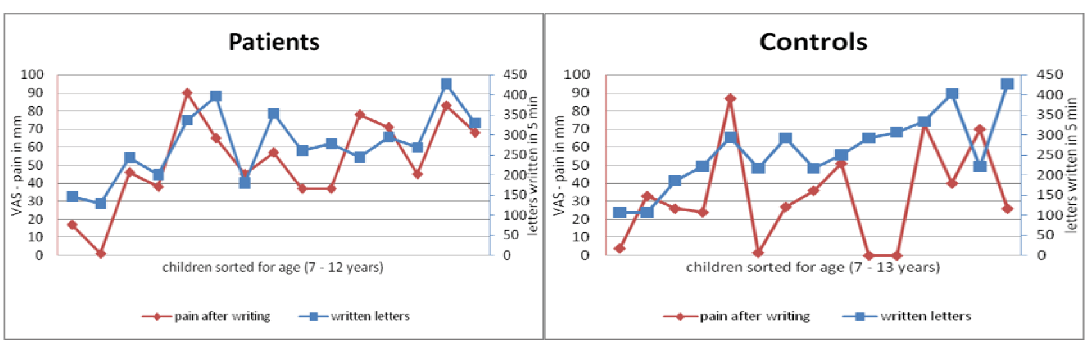

Figure 1: Correlation between letters written in 5 minutes and pain rated on the VAS-pain, in children with JIA (left) and controls (right). Children are sorted from youngest to oldest.

SYMPATHETIC ACTIVATION BY THE COLD PRESSOR TEST DOES NOT EXERT A POSITIVE INOTROPIC ACTION ON SKELETAL MUSCLES

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AIM: Sympathetic activation is known to influence the contractility of skeletal muscle fibers [1][2][3]. A positive inotropic effect (contractility potentiation) has been documented on type-II muscle fibers in both anesthetized animals and in-vitro experimental models. However, whether this mechanism mediates an effect with functional significance in physiological conditions remains a matter of debate. In this study, this issue is investigated by analyzing the changes induced in electrically stimulated (ES) contractions by the cold pressor test (CPT), a sympathetic activation stimulus that already proved to influence the contractility of type-I skeletal muscle fibers.

METHODS: Two experimental series were conducted. Contractions of the tibialis anterior (10 subjects, age, mean±SD, 23.6±3.0) and the soleus muscles (10 subjects, age 26.7±3.7) were induced by stimulating the peroneal nerve and the posterior tibial nerve, resp. The stimulation paradigm included single stimuli, doublets, and 5-s trains of stimuli and was performed before, during and after a CPT (hand immersed in water at 3-5°C). Peak amplitude, rise time and half relaxation time were estimated from single and double force twitches. Max torque and ripple amplitude were computed from the subtetanic contractions.

RESULTS: CPT induced a significant increase in arterial blood pressure and heart rate. No significant changes were observed in any of the parameters characterizing the contractions of the soleus muscle, whereas the tibialis anterior muscle exhibited a slight decrease in the amplitude of the force twitch evoked by both single stimuli (6.5±8.6 %; $P < 0.05$) and doublets (9.1±4.0 %; $P < 0.01$), without significant changes in rise time and half relaxation time. A weakening effect (8.4±10.5 %; $P < 0.05$) was also observed for the tibialis anterior muscle in the 10-Hz stimulated contractions.

CONCLUSION: The present experiment did not provide evidence of a positive inotropic effect of sympathetic activation on muscle fibers. Conversely, a small but significant weakening effect was observed in the tibialis anterior muscle, possibly indicating an action on type I muscle fiber. It is possible that the potentiating and weakening effects have masked each other or that the potentiating effect requires higher levels of sympathetic activation than the weakening effect on type-I fibers. Although appealing from the functional point of view for its consistent integration with the fight-or-flight response, the positive inotropic action on skeletal muscle fibers by physiological activation of the sympathetic nervous system remains to be demonstrated.

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REGIONAL EFFECTS OF PASSIVE JOINT ROTATION AND VOLUNTARY ACTIVATION ON SKELETAL MUSCLE ARCHITECTURE

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AIM: To quantify regional variation in the movement of muscle fascicles within the medial (MG) and lateral (LG) gastrocnemii muscles during passive ankle rotations and small, voluntary isometric contractions.
RATIONALE: Skeletal muscle architecture has been shown to vary between and within muscles. Different regions of a muscle may be activated to meet different mechanical demands and could provide different sensory feedback depending on the level of activation and change in muscle shape which may occur. The shape of a muscle will actively change during a contraction and will also change passively as a result of factors such as joint angle and movement of adjacent muscles. If changes in muscle shape differ between active and passive conditions, sensory receptors, such as muscle spindles, may provide feedback which enables the neuromuscular system to distinguish between movements which occur due to activation and those which are externally imposed. Determining regional variations in muscle architecture and their responses to different loading conditions has important implications for understanding how afferent feedback may be organised to help control posture and co-ordinate movement.
METHODS: Subjects stood on two footplates, with their ankles positioned to be coaxial with the axis of rotation of the plates. Strapping was placed around the waist, securing subjects to a vertical board and enabling them to remain standing with minimal activity in the calf muscles. Three B-mode ultrasound probes were placed over the gastrocnemii of the left leg, providing images from medial and lateral regions of MG and from the lateral region of LG. Images were recorded (25 Hz) during passive ankle rotations (ROM: 0.2^o, 2^o) and during small, voluntary isometric contractions with the ankle angle set at neutral (normal standing), dorsiflexed ($+5^o$) and plantar flexed (-5^o) positions.
An 8×10 grid of markers was placed over a representative image recorded from each muscle view, with the first and last rows corresponding to the superficial and deep aponeurosis, respectively. The position of each marker was then tracked through all subsequent images using a recently published algorithm (Loram *et al*., 2006 *J. Appl. Physiol.* **100**: 1311-1323), quantifying movement across each image with sub-pixel resolution. Data were grouped to assess marker displacement in deep/superficial and distal/proximal regions of each muscle view.
RESULTS: Grid markers placed over the deep portion of MG were found to move more than those over the superficial portion during passive ankle rotations. In addition, the larger ankle rotations (2^o) led to greater movement in the medial portion of MG compared to the lateral region. Voluntary isometric contractions led to much more homogenous displacements of markers in each recorded view in each muscle, with ankle angle having little influence on the recorded patterns.
CONCLUSION: Muscle architecture influences responses to passive muscle length changes and active contractions. Non-uniform fascicle architecture is therefore likely to influence both contraction mechanics and sensory feedback.
ACKNOWLEDGEMENT: This work was supported by The Wellcome Trust

HAPTIC FEEDBACK INFLUENCE IN BCI

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AIM: Motor imagery based brain computer interface (BCI) technology can be used in motor neurorehabilitation. The use of a BCI as a neuroprosthetic for paralyzed limb assistance implies afferent information flow caused by the feedback. It is an open question whether the proprioceptive feedback causes a bias in the modulation of a motor imagery based BCI control signal. The field of feedback in the BCI community has been a topic of interest for many groups. The question to answer is: what would be the best way to provide feedback to the users? A bar on a screen, cursors and lights are the most used feedback types. Recently vibrotactile feedback and robot control has been implemented. However feedback modality does not appear to be the most important factor concerning the performance using a BCI. Nonetheless if the goal of the BCI is to bridge the gap between the brain and a motor impaired limb with some afferent pathways intact, like in a chronic stroke patient, the sensory information coming back to the brain can produce some bias in our system. Stroke survivors with no residual movement in their hands are considered paralyzed and there are not available therapies for such individuals. BCI systems could be a potential solution for those who suffered a stroke and need to rehabilitate the limb and the brain at the same time. On the brain side, some groups performed some motor imagery based therapy improving the motor recovery of the patients. Some research groups have developed new methods using robots as a way of facilitating the therapist work gaining in repetition and movement control in all the rehabilitation sessions.

METHODS: In this work we coupled a mu rhythm based BCI on-line with a robotic hand orthosis fixed to the subjects hand for flexing or extending the subjects fingers. We wanted to study how the different movements and feedback could affect the performance using the BCI system coupled with the hand orthosis. We studied the proprioceptive or haptic feedback neurocorrelates and the performance of 10 subjects by comparing their accuracy using a BCI platform in 3 different tasks; Hand motor imagery task without feedback and motor imagery task with sham and contingent, proprioceptive feedback.

RESULTS: The proprioceptive feedback, either sham or contingent, increased the performance considerably for all the subjects, being higher in the contingent case. There is a clear desynchronization potentiation of the mu and beta rhythms while the subjects hand was being moved by the orthosis indicating a possible haptic feedback influence.

CONCLUSION: These findings could be very relevant for the motor neurorehabilitation field using BCIs and robotics.

NEW METHOD TO DETERMINE MUSCLE ACTIVATION DURING A FUNCTIONAL TEST BASED ON A BIMODAL GAUSSIAN MODEL OF SURFACE EMG SIGNALS

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AIM: The objective of this work was to develop an analytical method to objectively calculate threshold γ to determine muscle activation from surface EMG signals (sEMG), during the realization of a functional test, such as gait in healthy volunteers.
METHODS: The proposed method is based on the histogram of amplitudes *h* of a signal EMG(t) superimposed to a constant background noise n(t). EMG(t) is a series of successive muscle signals either at rest or active muscle state, each one has a Gaussian distribution. Muscle states are isolated by a functional test. The threshold γ is the amplitude value *y* where two Gaussian peaks intersect. Normal gait is used as a functional test to separate active muscle state from non active state. Method was tested on 1264 trials from 16 adults with no evident alterations on gait. Ages ranged from 24 to 61 years (mean 35.6 years). Informed consent was obtained from the volunteers. Bipolar surface EMG was recorded synchronously from the tibialis anterior, gastrocnemius, and soleus muscles. Electrodes selection and localization was according to the SENIAM recommendations. Foot switches were simultaneously used to define gait cycle. The raw EMG data were base-line processed with a 4^{th} order Butterworth filter with a cutoff frequency of 10 Hz. EMG signals were subsequently rectified and smoothed by a moving average filter with a window length of 100 ms.
RESULTS: The method is able to determine muscle activation from sEMG signals. On the left side of the figure 1, a good outcome of the method is shown. Linear envelope of sEMG signal is shown by blue line; red line represents the calculated threshold γ. On the right side of the same figure, calculated threshold γ is too high due to a high sEMG activity of tibialis anterior muscle during mid and terminal stance phase of gait cycle.

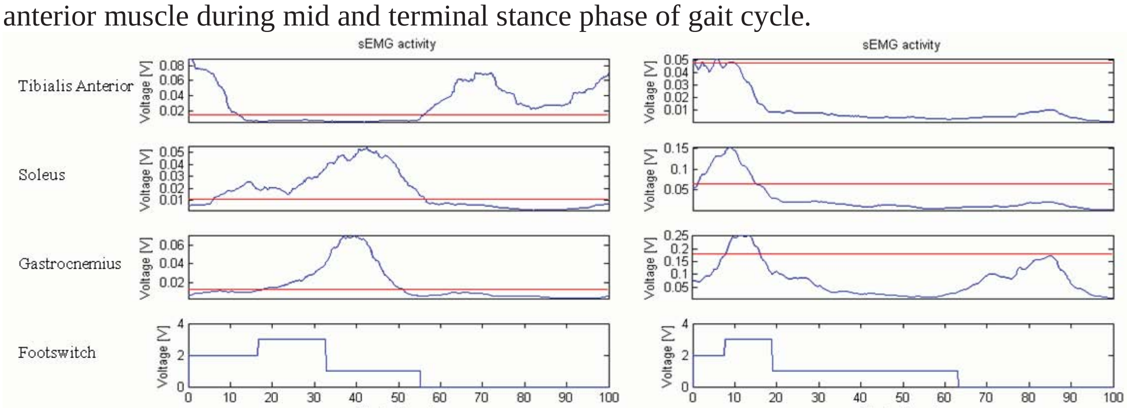

Figure 1: Output examples of threshold γ calculated for trial 1238 (left side) and trial 379(right side). Blue line shows linear envelope of sEMG signal. Red line shows the calculated threshold γ based on bimodal Gaussian model method.
CONCLUSION: The developed method for the determination of threshold γ based on bimodal distribution model is simple and suitable for practical application. This method does not rely on arbitrary decisions by the user and threshold γ is calculated automatically. The method can be used not only in normal gait but in any functional test able to isolate different muscles activity.

CROSS-CORRELATION BETWEEN MUSCLE ACTIVATION AND JOINT KINEMATICS OF GAIT CYCLE AT DIFFERENT CADENCES OF DIABETIC NEUROPATHIC INDIVIDUALS

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AIM: This study investigated the cross-correlation between muscles activity and the corresponding joint kinematics of lower limb of diabetic neuropathic (DN) and non-diabetics individuals walking in 2 cadences: self-selected and imposed (25% higher than self-selected).
METHODS: from 23 non-diabetics (CG) and 23 DN the EMG of vastus lateralis (VL), gastrocnemius medialis (GM), peroneus longus (PL) and tibialis anterior (TA) were assessed, as well as hip, knee and ankle kinematics during gait cycle. Cross-correlation function was applied to identify the strength of the phase relationship within each group and cadence between: (1) knee sagittal kinematics and VL activation, (2) ankle sagittal kinematics and GM, PL and TA activations. Correlation coefficients were compared between groups and cadences using ANOVAs 2-way for repeated measures.
RESULTS: Similar and moderate correlation were obtained between groups and cadences for the muscle activity and joint kinematics in all relationships (table 1). The correlation between the PL and ankle kinematics was higher for the DN individuals in the imposed cadence and the diabetics did not increase the PL activity in the load acceptance as the CG performed (figure 1).
CONCLUSION: The ankle stability in the load reception phase may have been compromised without a proper PL activation during the accelerate gait in the DN group and a safe gait progression with the challenge of gait cadence could not be successful achieved.

Table 1. Mean (and standard deviation) of cross-correlation coefficients (r) between muscle activation and joint sagittal kinematics of CG and DN group during both cadences: self-selected and imposed.

Phase Relationship	Cadence	r: CG (n=23)	r: DN (n=23)	P values: Group	P values: Cadence	P values: Group x Cadence
VL – Knee	Self-selected cadence	- 0.33 (0.18)	- 0.31 (0.17)	0.666	0.5554	0.4796
	Imposed cadence	- 0.30 (0.15)	- 0.34 (0.10)			
GM – Ankle	Self-selected cadence	0.51 (0.12)	0.55 (0.14)	0.205	0.938	0.777
	Imposed cadence	0.51 (0.07)	0.55 (0.11)			
PL - Ankle	Self-selected cadence	0.30 (0.28)	0.42 (0.21)	**0.028** §	0.408	0.912
	Imposed cadence	0.34 (0.09) §	0.44 (0.15) §			
TA - Ankle	Self-selected cadence	- 0.66 (0.13)*	- 0.68 (0.09)	0.415	**0.040** *	0.265
	Imposed cadence	- 0.62 (0.13)*	- 0.66 (0.10)			

§ represents statistically differences between groups (CG x DN); * represents statistically differences between cadences in each group (self-selected cadence x imposed cadence). Positive values indicated in-phase dominant coordination mode and negative values indicated anti-phase dominant coordination mode.

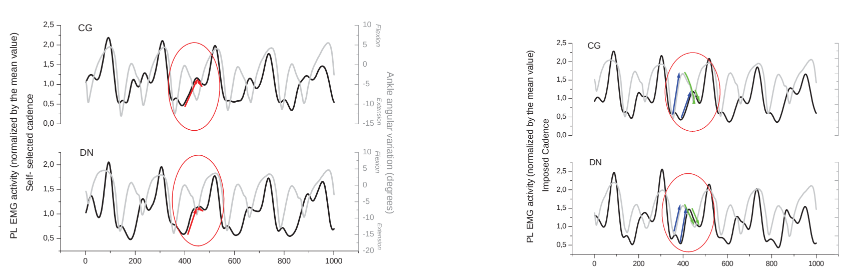

Figure 1. Time series of PL activation (black line) and ankle sagittal kinematics (grey line) of CG and DN during both cadences. Areas within the red ellipses highlight the distinct pattern of PL activation between groups at the end of swing phase and early support in both cadences. Red arrows point to the reduction in the PL activation in DN at the self-selected cadence. The blue and green arrows highlight ankle angular variation and PL activation in both groups at the end of swing phase and early support in the imposed cadence.

DIABETIC NEUROPATHY INFLUENCES COORDINATED ACTIONS BETWEEN MUSCLE ACTIVATION AND JOINT KINEMATICS DURING STAIR MANAGEMENT

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AIM: The aim of this study was to compare lower extremity EMG patterns and kinematics during stair management in diabetic neuropathic (DN) and non-diabetic individuals.
METHODS: Twenty three DN (DG) and 23 non-diabetics (CG) were tested during stair ascent and descent in a cadence of 96 steps per minute. The sagittal kinematics of hip, knee and ankle were synchronized with surface EMG signals of vastus lateralis (VL), gastrocnemius medialis (GM) and tibialis anterior (TA). It was used T-tests to compare groups (α=0.05).
RESULTS: In the stair ascent, DG presented lower ankle extension in the end of the stance phase. While projecting their body forward during the first half of stance, DG ankle flexion angle was smaller (table 1). Because of that, there was a worse ankle positioning in the beginning of the stance that is necessary for an efficient action of VL, the major responsible for the body elevation in this movement. Assuming that task and disease are symmetrical, and what happens in one limb occurs in the contralateral, it is supposed that the mechanical disadvantage of VL observed in DG at the beginning of the stance phase may have triggered an increased activation in the same muscle at the end of stance in the contralateral limb (figure 1). In the stair descent, DG had lower ankle extension at the beginning of stance, but did not show significant impairments in EMG (table 1).
CONCLUSION: the results reveal a negative influence of DN in muscle coordinated action with joint kinematics that was worse during stair ascent than during stair descent. The altered VL activation and ankle movement observed in DN individuals indicate an uncoordinated muscle action with lower joint movement to overcome the challenge of stair ascent. These motor deficits associated to higher vertical acceleration of these activities (in real life situations) may contribute to raise the risk of plantar ulceration compared to level walking.

Table 1: Mean (±1 sd) of joint sagittal kinematics of CG and DG during stair ascent and descent.

	ASCENT CG	ASCENT DG	P-value	DESCENT CG	DESCENT DG	P-value
Maximal Hip Flexion (degrees)	46.27 ± 6.98	43.94 ± 6.75	0.58	11.42 ± 3.16	11.76 ± 4.92	0.78
Maximal Knee Flexion (degrees)	61.44 ± 3.72	57.75 ± 4.17	0.28	67.27 ± 8.30	63.33 ±9.53	0.14
Maximal Ankle Flexion (degrees)	15.58 ± 6.20	13.02 ± 4.74	**0.01***	21.78 ± 4.48	20.14 ± 4.79	0.24
Maximal Hip Extension (degrees)	3.06 ± 7.46	3.19 ± 8.72	0.52	-0.09 ± 2.68	-0.44 ± 3.98	0.73
Maximal Knee Extension (degrees)	6.74 ± 7.30	6.19 ± 8.38	0.93	5.59 ± 4.31	6.38 ± 4.63	0.55
Maximal Ankle Extension (degrees)	-12.80 ± 2.47	-9.60 ± 3.70	**0.06#**	-27.45 ± 4.46	-23.90 ± 6.13	**0.03***

* indicate significant difference between groups (CG x DG). # indicate marginal difference between groups (CG x DG).

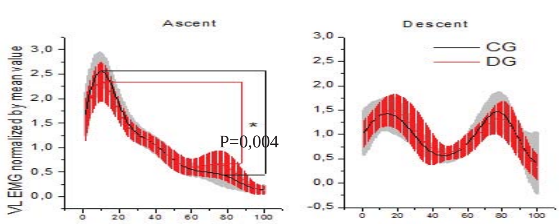

Figure 1: VL activation of DG (red line) and CG (black line) during stair ascent and descent. * indicate statistical difference between groups

ANALISIS OF THE SENSIBILITY TO FES OF PEOPLE WITH PATHOLOGICAL TREMOR

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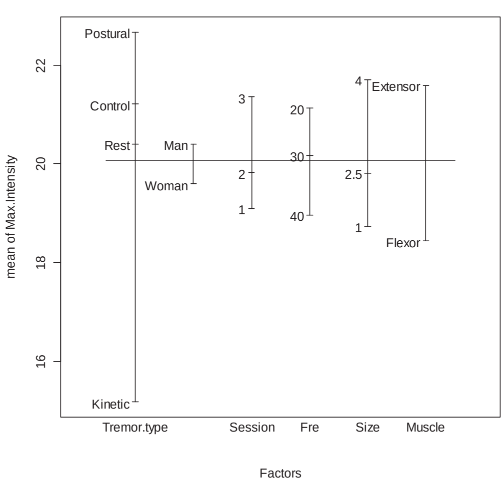
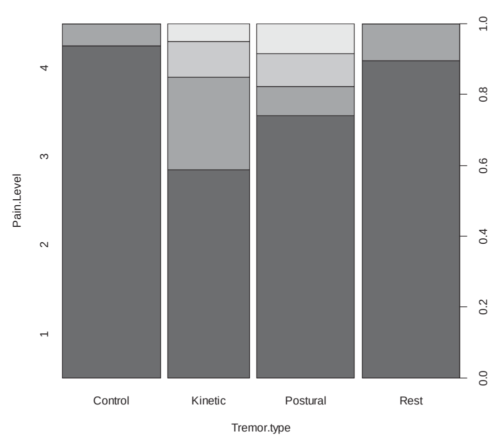
AIM: For being able of suppressing pathological tremor with FES the level of sensation produced by the system should be acceptable for the patients. This work aims at analyzing the sensibility to FES of different candidates pathologies for tremor suppression.
METHODS: 16 people took part in the analysis. 4 people of 3 pathologies corresponding to different types of tremor (Parkinson disease for rest tremor, Essential Tremor for postural tremor, ataxia for kinetic tremor) plus 4 control people without any kind of pathology. Two experiments were made simultaneously. In the first experiment a set of low levels of intensity were applied to each person. In the second experiment the intensity was increased to the maximum without a feel of discomfort from the user point of view. The other controlled variables have been: the size of the electrode, the frequency and the muscle (flexor carpi radials and extensor carpi radialis longus).
RESULTS: The people with kinetic tremor have reported higher levels of discomfort in both experiments (figure 1). More sensitivity have been found for narrower electrodes and for the flexor muscle (palmar side). Indeed, there is a clear adaptation between sessions (figure 1a). Surprinsingly for the frequencies of stimulation in the study (20Hz – 40Hz) decreasing frequency increases the tolerance to the stimulation suggesting that should be a maximum for comfort purposes.
CONCLUSION: People with kinetic tremor are not part of the target population using FES for tremor suppression, increasing the area of the electrodes and using frequencies of stimulation close to 20 Hz to improve sensibility and diminishing fatigue.



(a) Maximum intensity tolerated



(b) Pain level manifested

Figure 1: Mean of the maximum intensity tolerated for the main effects (a) and pain level manifested for the type of pathology (b).

ON THE IDENTIFICATION OF A MODEL FOR CONTROL OF FES TREMOR SUPPRESSION

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AIM: Differente kinds of control strategies have been proposed for FES. Some of them model-based, anothers using optimal control strategies or general purpose tools such as Artificial Neural Networks. In this paper we suggest to identify a simplified model to be indentified with the minimum number of measurements possible in order to achieve a reliable identification of the system each time the user is going to use it.
METHODS: The physiological model of Ferrarin (2001) has been used as the main input, the model has been re-modelled to allow a block identification of the system parameters for wrist flexion-extension. An orthogonal design of the whole model implies 19 measurements of each movement (flexion and extension). Measurements last for 2 s, enough to finish the slowest movements. The analysis of movement have been made by photogrametry.
RESULTS: Our approach is able to fit a reliable model of FES stimulation of the wrist with adjusted R^2 over 0.97. The model can be used as part of control loop or for guessing the initial conditions of an adaptive control reducing the number of steps for convergence with a reasonable time of initial measurements.
CONCLUSION: A simplified model of control of wrist flexion-extension for tremor suppression purposes has been proposed by using a block identification of all the parameters. The methodological approach considered reduces the number of measurement required to identify the system and can be part of a control loop. Despite, movement analysis was made using photogrammetry, but the same approximation is suitable with inertial sensors

Table 1: Fitting of the model for one user on both movements.

	Extension		Flexion	
	Estimation	P-Value	Estimation	P-Value
(Intercept)	-682 ± 91	<0.001	758 ± 53	<0.001
Alpha	-2.8 ± 0.2	<0.001	-1.5 ± 0.1	<0.001
I(Theta^2)	2316 ± 17	<0.001	2986 ± 23	<0.001
Omega	-61.7 ± 3.7	<0.001	-57.1 ± 2.4	<0.001
I(Omega^2)	24.6 ± 3	<0.001	23.1 ± 2.3	<0.001
Freq	-5.4 ± 0.7	<0.001	0.8 ± 0.4	0.064
Int	4.7 ± 1.2	<0.001	-0.4 ± 0.8	0.667
PWD	6.5 ± 1	<0.001	-7.7 ± 0.6	<0.001
I(Freq + Int + PWD^2)	-0.021 ± 0.004	<0.001	0.026 ± 0.002	<0.001
I(Freq + Int + PWD^3)	2.3e-5 ± 4.4e-6	<0.001	-3.0e-5 ± 2.5e-6	<0.001
Freq:Int	0.29 ± 0.03	<0.001	-0.03 ± 0.02	0.171
Freq:PWD	0.015 ± 0.002	<0.001	-0.003 ± 0.001	<0.001
Int:PWD	-4.8e-3 ± 4.3e-3	0.26	1.2e-2 ± 2.7e-3	<0.001
Freq:Int:PWD	-8.3e-4 ± 1.1e-4	<0.001	1.3e-4 ± 7.0e-5	0.058

ACTIVATION PATTERN OF UPPER AND LOWER TRAPEZIUS DURING A FUNCTIONAL TASK IN PATIENTS WITH SHOULDER IMPINGEMENT COMPARED TO HEALTHY CONTROLS

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AIM: A muscular activity imbalance with high activity in the upper compared to the lower parts of the trapezius muscle, is claimed to be present in subjects with shoulder impingement, a painful condition in the shoulder. Rehabilitation of impingement has therefore aimed at reducing the muscle imbalance by guided assistance in increasing the lower trapezius muscle activity, while maintaining a low upper trapezius muscle activity. If the evidence behind this rehabilitation holds true, a muscular imbalance must also be present during functional activities, and not only, as mostly found, during standardized tasks, in eg. supine lying.
The aim of this study was to examine whether a muscle imbalance (reduced lower trapezius activity, higher upper/lower trapezius ratio and a delayed onset of lower trapezius muscle activity relative to the upper trapezius muscle) is present during a functional task in subjects with shoulder impingement *(imp)* as compared to subjects without impingement *(no-imp)*.
METHODS: Totally, 29 subjects (15 with and 14 without shoulder impingement) (mean age 42 yrs, SD13.9; 38 yrs, SD 12.0) were included. Inclusion criteria for cases were at least 30 days with pain/discomfort in the shoulder/neck region within the last year, and 2 or more positive impingement tests, while for controls it was less than 8 days with pain/discomfort in the same area within the last year, and no positive impingement tests. Electromyography (EMG) (in %MVE, maximum voluntary EMG) was measured and calculated from three subdivisions of the trapezius muscle, during arm elevation 0-170° and lowering 170-0° in the scapular plane, with no load (NL), 1 kg and 3 kg hand held load, with five repetitions of each load type. The analyses were performed during 60-120° elevation and lowering, to describe the painful arc of motion. Mean activity of trial 2, 3 and 4, the ratio of upper to lower trapezius muscle activity and time to activity onset (sec) was calculated for each subdivision. An unpaired t-test was applied to test for differences between groups (significance if $p<0.05$, a tendency if $0.05<p<0.1$).
RESULTS: A trend to higher muscle activity (%MVE) was seen in all muscle parts in *imp* compared to *no-imp*, most clearly for the middle trapezius during elevation with NL (22.7 vs 14.4; p=0.08). There was no difference between groups in the upper/lower muscle activity ratios. A significant delay (sec) in activity was seen for *imp* in the middle trapezius in relation to the upper trapezius, in 3 kg elevation (-0.102 vs 0.017; p=0.021). Subjects with *imp* also tended to activate the lower part later than upper part during all loads.
CONCLUSION: A poorer muscle activity balance within the trapezius muscle seems to be present in subjects with *imp*, seen as a higher general muscle activity and a delayed activation of the middle and lower trapezius parts. Based on the present data, it seems reasonable in rehabilitation to focus on guidance for increasing the lower trapezius muscle activity, relative to the upper trapezius muscle activity during functional tasks.
ACKNOWLEDGEMENT: This study was supported by the National Research Fund for Health and Disease, the Research Fund for the Region of Southern Denmark, and The Arthritis Research Association.

CONCEPTUAL DESIGN OF A FES SYSTEM FOR TREMOR SUPPRESSION

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AIM: Outline a conceptual design of a FES system BCI (Brain Computer Interface)-driven acceptable for daily use by tremor patients. The system will consist of a control box with batteries, textile electrodes sewn on a sleeve and a system for recording the EEG signals of the motor cortex.
METHODS: A focus group with tremor patients has been done to grasp their needs and their point of view about the acceptability of a wearable system for tremor suppression, and to understand the limits of usage depending on the characteristics of the system. Taking into account the technical requirements of the different parts of the system an orthogonal design experiment has been made for the assessment of the acceptability of the different design possibilities and the search for the best solution. The analysis has been done using the conjoint methodology.
RESULTS: The main restrictions on the users point of view for a system for tremor suppression are on the social part. It must be taken into account that one of the disabling aspects of tremor is social aestigma. Therefore, the system cannot be visually intrusive. With respect to the acceptance of the different designs, users are more concern with respect the BCI part, because they feel it as very intrusive. Subsequently they prefer the solutions less visible. With respect the design of the control box, users prefer the system to be located close to the wrist without caring very much about the size, as long as the system can resemble a daily electronic good such as an mp3 player.
CONCLUSION: Design of an acceptable system for tremor suppression in real life conclusions has to deal with patient preferences, and tremor pathologies seem to be very restrictive in their acceptance due to the risk of perceived social aestigma. Subsequently, tools coming from user-centered design has been used to achieve a conceptual design acceptable for the intended users.

Figure 1: A view of the different components of the system for tremor suppression using FES.

MOTOR UNIT RECRUITMENT DURING ELECTRICAL STIMULATION

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Electrical stimulation incorporates the use of electrical current to activate skeletal muscle and facilitate contraction. It is a commonly used modality in clinical settings to mimic voluntary contractions in an effort to enhance the rehabilitation and performance of human skeletal muscles. Although the beneficial effects of electrical stimulation may be widely accepted, discrepancies concerning the specific responses of motor units to electrical stimulation versus voluntary actions exist. The unique effects of electrical stimulation have been attributed to several mechanisms, most notably a reversal of the recruitment pattern typically associated with voluntary muscle activation. The purpose of this presentation is to present an evidence-based view that muscle fiber recruitment during electrical stimulation is in a nonselective, spatially fixed, and temporally synchronous pattern. Evidence will be presented from both metabolic and mechanical data sources as well as several others. Furthermore, the presentation will synthesize the evidence that supports this recruitment pattern contributes to increased muscle fatigue when compared with voluntary actions. A greater understanding of how electrical stimulation recruits motor units is highly relevant when using this modality for testing and training in exercise and sport.

LOW-DENSITY HIGH-SURFACE-AREA ELECTROMYOGRAPHY OF THE CALF MUSCLES DURING CONCENTRIC AND ECCENTRIC LOADING

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AIM: Achilles tendinopathy is common in both active and sedentary populations. The main conservative treatment is heavy load eccentric training (ET) of the triceps surae, however, the mechanisms that underlie the efficacy of this intervention remain unclear. It is likely that the whole triceps surae unit is involved in mechanical remodelling, not just the Achilles tendon. The aim of our study was to compare eccentric and concentric loading modalities to investigate differences in muscle activity and tendon force (TF) across the triceps surae by low density high-surface-area electromyography (LDHsEMG). Conventional surface EMG assumes the electrical field of a muscle belly to be uniform throughout its length. We hypothesise that the electrical field is both non-uniform and likely to differ between normal subjects versus subjects diagnosed with Achilles tendinopathy and from pre to post therapeutic intervention.
METHODS: We will measure LDHsEMG using 16 channel wireless sEMG at 1500 Hz during a series of timed heel raises and heel drops in two groups of 10 people; controls and athletes with Achilles tendinopathy. Heel raises and drops will be performed on a purpose made step positioned directly above a force plate for vector measurement of vertical ground reaction force. Simultaneous infra-red motion data, sampled at 200 Hz, will be captured using an active marker system. Movement of the infra-red markers will be time-stamped and registered to the LDHsEMG activity for each time-step. Prior diagnosis and injury localisation will be confirmed by clinical examination and MRI. Movement-registered sEMG data will be analysed using power spectral analysis and compared between movements and between groups.
RESULTS: Sample data of the hamstring is shown in pictorial form for one subject (Figure 1) as a proof of principle for data capture. Full results for the calf will be available in late April.
CONCLUSION: The novel methods of data collection and analysis will yield useful information about muscle activation of the posterior lower leg during different movements and injury conditions.

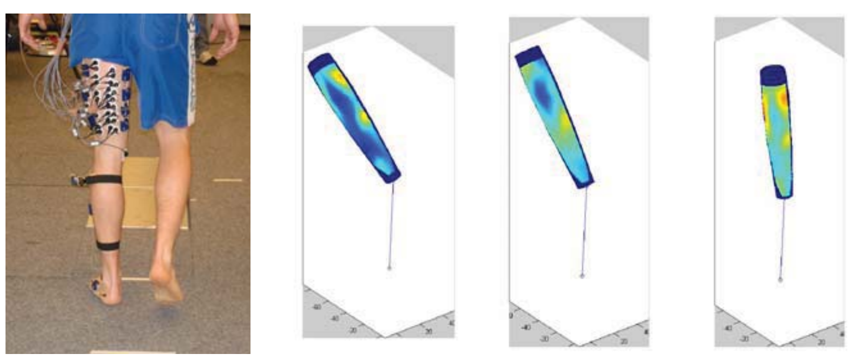

Figure 1: a) Experimental set-up of LDHsEMG on the posterior thigh, in this case used in capturing 16 channel sEMG and motion data b) example of movement and sEMG data with false colour topographical map showing non-uniform hamstring muscle activation during different epochs of the gait cycle (low, blue – high, red)

DETERMINANTS OF MOTOR UNIT POTENTIAL COMPLEXITY

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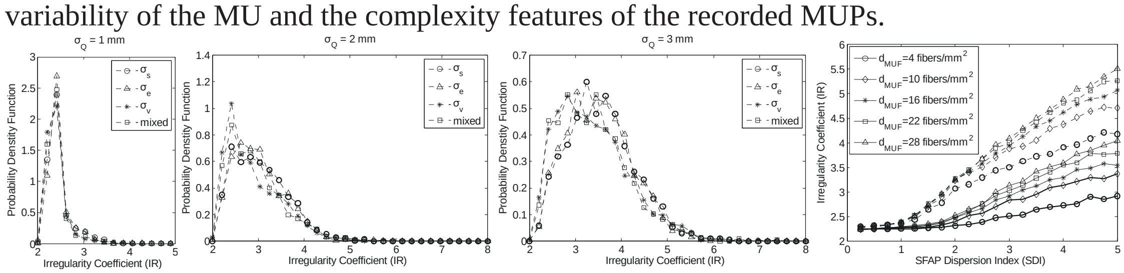
AIM: To determine and quantify the influence of anatomical and physiological features of the motor unit (MU) on the recorded motor unit potential (MUP) waveform complexity.
METHODS: A measure of the temporal dispersion of the single fiber action potentials (SFAPs) contributing to a MUP, the SFAP dispersion index (SDI), is mathematically obtained as a function of the statistical distribution moments (mean and variance) of the involved physiological parameters: initiation of depolarization (IoD), motor end-plate positions (MEPP), and muscle fiber conduction velocities (MFCV) [1]. Two different simulation experiments are carried out to validate the usefulness of the SDI, and relate it to the irregularity coefficient (IR) [2] of the synthetic MUPs. An overall of 10,000 simulated MUPs were obtained under different combinations of the IoD, MEPP, and MFCV distributions, as well as for different values of the MU fiber density (MUFD).
RESULTS: Simulations show that mean and variance of the IR distribution increase as the SDI increases. Moreover, the IR distributions for a given SDI value are the same, regardless the source of the SFAPs dispersion (Fig. 1(a-c)). This suggests that the SDI is adequately combining all the information about SFAPs temporal dispersion attributable to the different sources of variability among fibers within a MU. An additional dependence of the IR on the MUFD can be observed (Fig. 1(d)). When MUFD increases a general increase of the IR is observed, although in very low SDI cases, when MUFD increases IR may decrease. We call this the *saturation effect* of the MUP. Simulations also show that IR distributions are much more sensible to SDI changes than to MUFD changes. This may explain why MUP complexity is a very good feature to discriminate between normal and pathological MUPs, but fails in the classification of myogenic and neurogenic MUPs [2].
CONCLUSION: A new parameter to quantify the temporal dispersion of the SFAPs has been obtained. The SDI provides a new tool to study the relationship between the physiological variability of the MU and the complexity features of the recorded MUPs.



(a) (b) (c) (d)

Figure 1: (a-c) IR distributions for three different SDI values (σ_Q) obtained under different combinations of the physiological sources of dispersion (IoD: σ_s, MEPP: σ_e, and MFCV: σ_v); **(d)** IR 25th and 75th percentiles as a function of the SDI for different MUFD values.

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THE POSTURAL RESPONSE OF THE PELVIC FLOOR MUSCLES DURING ACTIVE STRAIGHT LEG RAISE TEST IN WOMEN WITH AND WITHOUT PELVIC GIRDLE PAIN POSTPARTUM

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AIM: To evaluate the postural response of the pelvic floor muscles (PFM) during active straight leg raise (ASLR) tests performed at a comfortable speed in women with pelvic girdle pain (PGP) and in pain-free women postpartum.
METHODS: Eight women with PGP and 10 pain-free women were included. A clinical examination was performed to verify that the women with PGP fulfilled the criteria for PGP used in this study. The criteria were: ≥ 2 positive sacroiliac joint pain provocation tests, pain located distal and/or lateral to the L5-S1 area in the buttocks with absence of centralization or peripheralization, and no lumbar effect of repeated movements according to the classification of Mechanical Diagnosis and Therapy protocol. Electromyographic (EMG) activity was recorded from the PFM with Periform™ vaginal probe. Activity was recorded unilaterally from the transverse abdominal/internal oblique, rectus abdominal, hip adductors and the rectus femoris muscles with surface electrodes. The women performed repeated ASLR tests, first with one leg and then with the other leg. The lift performed with the contralateral leg with respect to the electrodes on the trunk will further out be referred to as the contralateral ASLR. Activity from the hip adductors was recorded from the contralateral leg during the ipsilateral ASLR while the activity from the rectus femoris always was recorded from the leg performing the lift. The contralateral ASLR was also performed with a weight strapped to the ankle. EMG signals were sampled at 1000 Hz by the MESPEC 4000 EMG unit system (MEGA Electronics Ltd, Finland). The EMG onsets were related to the start of the movement and they were calculated using MATLAB (The MathWorks Inc., USA).
RESULTS: One woman with PGP experienced difficulties with performing the ASLR test during the clinical examination. The onset of the PFM was presented before the start of the three ASLRs in all pain-free women and in all women with PGP except in one ($P > 0.05$). The median onset of the rectus femoris occurred before the start of the contralateral ASLR ($P = 0.04$), the contralateral ASLR with an extra weight ($P = 0.02$) and the ipsilateral ASLR in both groups ($P > 0.05$). The onset occurred earlier in the PGP group than in the pain-free group. The median onset of the abdominal muscles and the hip adductors occurred before the start of the two ASLRs with no extra weight but after the start of the ASLR with the extra weight in the PGP group. The median onset of the abdominal muscles occurred after the start of the two ASLRs with no extra weight but before the start in the ASLR with the extra weight in the pain-free group. The median onset of the hip adductors occurred before the start of the lift during the contralateral ASLR with an extra weight and the ipsilateral ASLR but not during the contralateral ASLR in the pain-free group. There was a difference between the groups regarding the onset of the transverse abdominal/internal oblique ($P = 0.02$) and the hip adductors ($P = 0.02$) muscles during the contralateral ASLR.
CONCLUSION: The findings suggest a postural response of the PFM prior to the start of the ASLRs performed in a comfortable speed in women with and without PGP postpartum. Also, the results indicate that women with PGP who experience difficulties with performing the ASLR test have a different postural response of the PFM compared to the women with PGP that experience no difficulties with performing the test.

THE ROLE OF MUSCLES IN SPORT PERFORMANCE: EXPERIMENTAL AND THEORETICAL CONSIDERATIONS IN BICYCLING

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AIM: The aim of our work in bicycling has been to study optimal performance from a muscle properties point of view. Muscle properties that have been considered in our work include the force-length and force-velocity relationships and history dependent force production of the lower limb musculature.
METHODS: Our theoretical work has been aimed at studying geometrical parameters in bicycling (seat height, trunk alignment, pedal length and pedal frequency) that allow for maximal power output in bicycling. Muscle properties were obtained by direct ergometer testing and/or the literature, while optimizations were performed using custom-written software. Our experimental work has focused on the mechanical properties of selected lower limb muscles and how these properties are used during bicycling. Muscle mechanical properties and contractile conditions were mostly obtained through ergometer testing and ultrasound imaging.
RESULTS: Our theoretical results gave predictions of optimal bicycle-rider geometry for maximal power output. Most surprisingly, we predicted that maximal power output occurs at a pedal frequency of approximately 150 revolutions per minute (rpm), which coincides with what track sprinters use in a 200m flying time trial event, while laboratory testing typically gives maximal power output for pedaling at 105-120 rpm. Our experimental results showed that force-length properties of the lower limb muscles adapt to chronic exercise training as experienced by cycling, that history-dependent force production in muscles reduces power output by up to 20% compared to when neglecting these effects, and that fascicle lengths decrease substantially for a given crank angle when power output increases. Surprisingly, this shift in fascicle lengths appears to be matched by a corresponding shift in the force-length properties of the muscles so that fascicles during cycling always operate across the plateau of the force-length relationship
CONCLUSION: The force-length property and fascicle lengths change in tandem with changing power requirements during cycling such that fascicle excursions always cover the plateau of the force-length relationship. This finding provokes the intriguing hypotheses that fascicle length changes at different levels of effort are magically matched with the corresponding shift in the force-length properties. This result is insofar intriguing as the fascicle length changes at different efforts are related to the mechanical stretching of series elastic components while the shift in the force-length relationship is associated with an increased calcium sensitivity of muscles at long length and sub-maximal efforts.
ACKNOWLEDGEMENT: NSERC of Canada

EFFECT OF FATIGUE ON MUSCLE-TENDON STIFFNESS AND NEUROMUSCULAR PERFORMANCE IN CYCLISTS

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AIM: It was previously demonstrated that muscle-tendon stiffness (MTS) of quadriceps is a factor determining sprint ability in cyclists in non-fatigued condition (Watsford et al, 2009). Indeed, the peak rate of crank torque development (RCTDpeak) was higher in stiffer cyclists. The aim of the present study was to ascertain whether stiffer cyclists are still better at sprinting in fatigued condition, thus trying to simulate what it really happens during road cycling competitions.
METHODS: Twenty-one trained male competitive endurance cyclists (28.7±9.5 yr, 1.74±0.08 m, 67.5±7.2 kg) volunteered to participate in this project. Unilateral MTS of quadriceps was assessed by means of a free-oscillation technique (Walshe et al, 1996). In addition, peak power output (POpeak), crank torque peak (CTpeak), RCTDpeak were assessed on a bicycle ergometer using a 6-second sprint (S1). The cyclists were then required to pedal during 3 stages of 3 minutes each at intensities of 30%, 35% and 40% of POpeak respectively. At the end of each stage, a 6-second sprint was performed (S2, S3, S4 respectively), followed by 1 min pedalling at 100W. Bipolar surface EMG of vastus lateralis was recorded throughout the 4 sprints (S1, S2, S3, S4), with the signal processed off-line to obtain the integrated EMG (iEMG) and the median frequency of power spectrum (MDF). Cyclists were divided into a stiff (SG) and a compliant group (CG) with a median-split technique, according to their MTS level. Data were analysed adopting a 2-way repeated measures ANOVA.
RESULTS: The cycling protocol proved to be effective in inducing fatigue. Indeed, POpeak was reduced by 20% in S4 compared to S1. Furthermore, a reduction in iEMG was observed ($p<0.01$), along with a quasi significant ($p=0.06$) decrease in MDF (table 1). Interestingly, this decrease became significant ($p<0.05$) when the SG were analyzed independently from CG (table 1). Following the fatigue protocol, MTS was reduced ($p<0.01$) in SG only (from 2377±692 to 1946±801 $Nm^{-1}rad^{-1}$). Similarly, only SG exhibited a decrease in CTpeak and RCTDpeak ($p<0.05$).
CONCLUSION: The main outcome of this study is that fatigue affects stiff and compliant cyclists differently. A fatigue-related decrease in MTS in SG coincided with reductions in CTpeak and RCTDpeak which reached approximately the level of CG. The significant MDF decrease observed in SG only could be associated to a higher percentage of fast-twich fibers in stiffer cyclists compared to CG (Komi and Tesch, 1979).

Table 1: Mean (SD) of the main variables measured in pre- and post-fatigue condition.

	CTpeak (Nm)		RCTDpeak ($Nm\ s^{-1}$)		EMG MDF (Hz)	
	S1	S4	S1	S4	S1	S4
All cyclists	144.4 (21.3)	123.3 (20.5) †	1301.8 (230.5)	1139.3 (181.4) *	75.4 (13.5)	71.6 (10.3)
CG	140.1 (18.4)	123.9 (19.4)	1213.8 (189.0)	1137.7 (162.7)	72.6 (14.9)	71.77 (9.7)
SG	151.1 (23.1)	124.7 (22.7) *	1411.9 (234.2) [a]	1170.8 (188.8) *	79.2 (11.8)	73.4 (9.8) †

Significant different from S1: * $p<0.01$; † $p<0.05$; [a] Significant different from CG ($p<0.05$).

MODEL SIMULATION OF THE INTERACTION BETWEEN MUSCLE FIBRE CONDUCTION VELOCITY AND FIRING RATE

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AIM: The aim of this study was to investigate the interaction between muscle fibre conduction velocity (MFCV) and instantaneous firing rate observed during electrically elicited and voluntary contraction using model simulation.
METHODS: A model of the propagating muscle fibre action potential was developed, incorporating both the surface and tubular membranes. The tubular membrane included the ionic currents present in the surface membrane with the addition of a third K^+ channel characterized by a slow conductance change. The model was used to examine the relationship between MFCV and interpulse interval, referred to as the velocity recovery function (VRF), and the interaction between MFCV and the instantaneous firing rate during simulated voluntary contraction.
RESULTS: The shape of the simulated VRF was similar to that recorded experimentally (Mihelin et al. 1991, Z'Graggen et al. 2009), with the supernormal part resulting from the early and late afterpotentials of the muscle fibre action potential, Figure 1(a). Increasing the number of conditioning pulses caused the first phase of the VRF curve to decrease due to increased K^+_o accumulation and the second phase to increase due to the increased negativity of the late afterpotential. A positive correlation between MFCV and firing rate was observed, Figure 1(b), and was found to be due to the negative slope of the VRF curve from 5 - 40 Hz, Figure 1(a), consistent with previous experimental observations (Farina et al. 2008).
CONCLUSION: The simulation results support the hypothesis that changes in the membrane potential during the early and late afterpotentials in muscle may be responsible for the supernormal part of the VRF observed during electrically elicited and voluntary contraction.

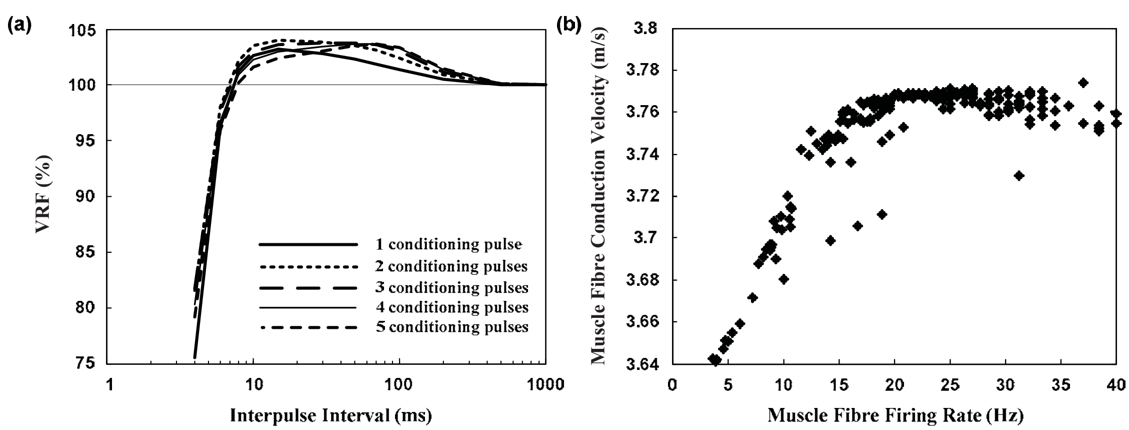

Figure 1: (a) VRF for 1-5 conditioning pulses and (b) relationship between muscle fibre conduction velocity and instantaneous firing rate.

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VALIDATION OF CKC SURFACE EMG DECOMPOSITION IN A PENNATE MUSCLE

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AIM: The purpose of this study was to assess the accuracy of high-density surface EMG (HDsEMG) decomposition in the biceps femoris muscle (BF) by comparing the results with those obtained from decomposition of simultaneously recorded intramuscular EMG (iEMG).
METHODS: Five subjects, four males and one female aged between 28 and 50 years old participated in this study. They were asked to lay prone on a bed with the knee flexed 45° from full extension. An array of surface electrodes (13 rows × 5 columns with 8 mm inter-electrode distance) was placed along a line from the ischial tuberosity to the lateral side of the popliteal fossa. Four columns were used to record surface HDsEMG while three needles were used to record iEMG signal from the middle column. Twenty-second-long iEMG and HDsEMG signals were recorded simultaneously at low force isometric contractions. The HDsEMG signals were decomposed using the CKC algorithm [1], and the iEMG signals were decomposed using the EMGlab program [2]. MUAP trains detected in common in the HDsEMG and iEMG signals were compared, and the percentage of firings for which the two decompositions agreed to within ±0.5 ms was determined.
RESULTS: A total of 43 contractions were analyzed. On average, from 3 to 7 MUAP trains were detected in common per contraction. The agreement rate was 82 ± 5% (mean ± std).
CONCLUSION: BF is a pennate muscle with short fibers. The surface MU potentials identified by EMG decomposition were mostly standing waves in which propagation could not be detected. Nevertheless, the CKC decompositions were valid and accurate, as demonstrated by the agreement with the iEMG results. As an example, the firing patterns of 22 MUAP trains identified by the CKC algorithm from one contraction of BF are shown in Figure 1.

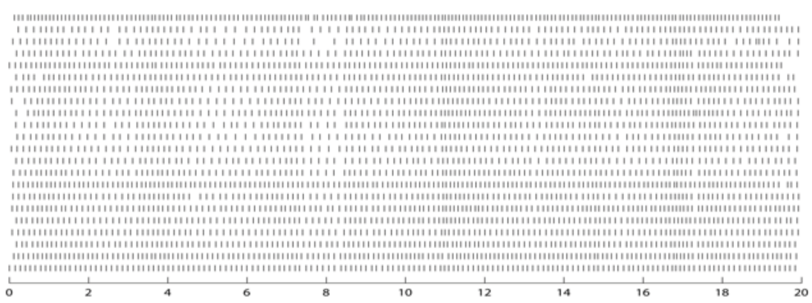

Figure 1: The firing times of 22 motor units identified from HDsEMG of biceps femoris muscle using the CKC algorithm. Each vertical line denotes one motor unit firing.

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IS INTERINDIVIDUAL VARIABILITY OF EMG PATTERNS IN TRAINED CYCLISTS RELATED TO DIFFERENT MUSCLE SYNERGIES?

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AIM: The purpose of the present study was to determine whether the relatively high interindividual variability in electromyographic (EMG) patterns during pedaling is related to different muscle synergies and, consequentially to variability in the motor program.
METHODS: Nine trained cyclists were tested during a constant-load pedaling exercise performed at 80% of maximal power tolerated. Surface EMG signals were measured in ten lower limb muscles. A decomposition algorithm (non-negative matrix factorization) was applied to a set of forty consecutive pedaling cycles to differentiate muscle synergies. We selected the least number of synergies that provided 90% of the variance accounted for (VAF).
RESULTS: Using this criterion, the similar three synergies were identified for all the subjects and accounted for 93.5±2.0% of total VAF, with VAF for individual muscles ranging from 89.9±8.2% to 96.6±1.3%. Despite a large consistency in the weighting coefficients across subjects for several monoarticular muscles, the results show larger intersubject variability for another monoarticular muscle (*Soleus*) and for biarticular muscles (*Rectus femoris, Gastrocnemius lateralis, Biceps femoris and Semimembranosus).*
CONCLUSION: This study demonstrated that the pedaling task is accomplished by the combination of the similar three muscle synergies among trained cyclists. The interindividual variability of EMG patterns observed during pedaling does not represent differences in the overall motor program, but rather represents differences in the contribution of some muscles to the muscle synergies that could be explained by differences in body morphology.
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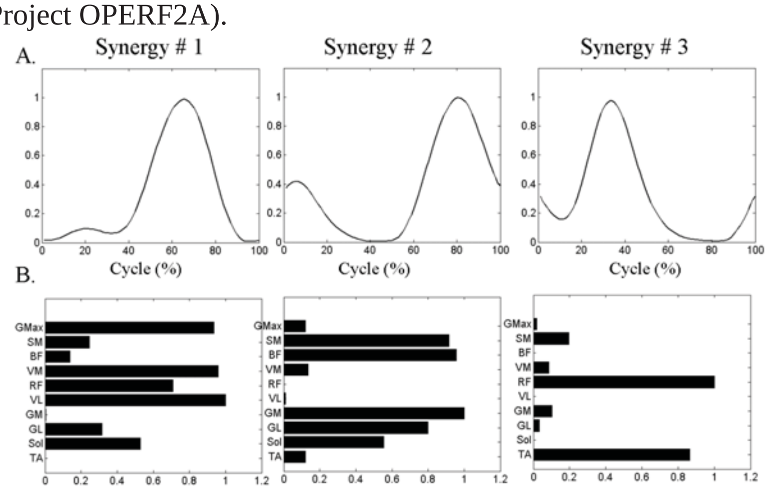

Figure 1: Individual example of the three extracted synergies. A/ synergy activation coefficient and B/ muscle synergies (weighting coefficients). The synergy activation coefficients are expressed as a function of the percentage of the pedaling cycle as it rotated from the lowest pedal position (BDC, 0%) to the highest (TDC, 50%) and back to BDC to complete a 360° crank cycle.

ATLAS OF THE MUSCLE MOTOR POINTS FOR LOWER LIMB MUSCLES

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AIM: To investigate the uniformity of the muscle motor point location for muscles of the lower limb in healthy subjects and to provide indications for proper positioning of the stimulation electrodes over the investigated muscles.
METHODS: Forty healthy subjects of both genders (age range: 18-55 ys) were recruited and evaluated. The main muscle motor points were identified for the following ten muscles of the lower limb (dominant side): vastus medialis, rectus femoris, and vastus lateralis of the quadriceps group, hamstrings muscles (biceps femoris, semitendinosus, and semimembranosus), tibialis anterior, peroneus longus, lateral gastrocnemius, medial gastrocnemius. The muscle motor point was identified by scanning the skin surface with a stimulation pen electrode (small size cathode: 1-cm^2 surface) and corresponded to the location of the skin surface generating the maximal mechanical response with the minimum injected current. For each investigated muscle, square pulses were delivered through the pen electrode at low current amplitude (<10 mA) and frequency (2 Hz) and a large electrode (50x80 mm) was placed over the antagonist muscle to close the stimulation current loop (monopolar stimulation).
RESULTS: Sixteen motor points were identified in the ten investigated muscles of the lower limb: 3 motor points for the vastus lateralis, 2 motors point for rectus femoris, vastus medialis, biceps femoris, and tibialis anterior, 1 motor point for the remaining muscles (an example of the motor points identified for the gastrocnemii muscles is reported in Figure 1). An important inter-individual variability has been observed for the location of 8 out of 16 motor points, especially for the motor points identified in the hamstrings and gastrocnemii muscles.
CONCLUSION: These observations have relevance to develop guiding recommendations for proper positioning of the stimulation electrodes, in order to increase standardisation and effectiveness of the stimulation procedures.
ACKNOWLEDGEMENT: Supported by Regional Health Administration Project “Ricerca Sanitaria Finalizzata” and by Compagnia di San Paolo Project “NICEM”.

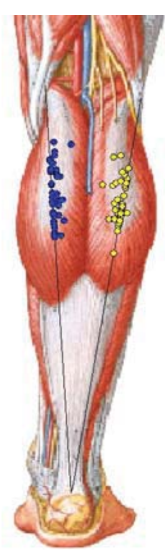

Figure 1: Position of the motor points for the medial (blue circles) and lateral (yellow circles) gastrocnemii muscles in forty healthy subjects. The average (±SD) position of the motor point along the reference line (continuous black line) was 27 (±7)% (percentage of the distance from the medial knee joint line to the posterior superior portion of the calcaneal tuberosity, starting from the medial knee joint line) for the medial gastrocnemius and 27 (±5)% (percentage of the distance from the apex of fibular head to the posterior superior portion of the calcaneal tuberosity, starting from the apex of fibular head) for the lateral gastrocnemius.

EFFECT OF MEDIAL HAMSTRING FATIGUE BY ELECTRICAL STIMULATION DURING DROP JUMP LANDING

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AIM: Muscle fatigue around the knee joint supposed to be associated with knee kinematics. Although a great number of reports are available on electromyographic (EMG) activity of the muscles around the knee joint in fatigue condition, few has been reported in individual muscle fatigue condition. The purpose of the present study was to determine whether fatigue in an individual muscle alters the EMG activity during landing task.
METHODS: Subjects were 7 healthy young men; all subjects participated in experiments 1 and 2. Experiment 1 investigated individual muscle fatigue of the semitendinosus (ST) muscle. Transcutaneous electrical muscle stimulation (EMS) was applied to the medial hamstring for 30 min with the intent of stimulating and fatiguing the ST muscle. One electrode was placed over the belly of the ST muscle, and the other was placed distal to the muscle. Before and after EMS, the subjects performed 25%, 50%, and 75% of the maximum voluntary isometric contraction of the knee flexion muscles. We recorded the surface EMG signals from the ST, semimenbranosus (SM), and biceps femoris (BF) muscles. Integrated EMG amplitude and median power frequency (MDF) values were calculated using the collected data. In experiment 2, we examined the EMG activities during single leg landing of the 40cm drop jump. The EMS procedure used in experiment 2 was the same as that used in experiment1. Surface EMG signals were collected from the rectus femoris, vastus medialis, vastus lateralis, medial hamstring, lateral hamstring, tibialis anterior, medial and lateral heads of the gastrocnemius muscles. We calculated the average rectified values during the landing phase. The calculated data from experiment 1 and 2 compared between before and after EMS.
RESULTS: MDF values for each muscle in experiment 1 were plotted (Figure 1). The MDF value of the ST muscle significantly decreased during all levels of contractions. The MDF values of the SM and BF muscles were not significantly altered. In experiment 2, average rectified values between before and after EMS tasks were different.
CONCLUSION: EMS of the medial hamstring selectively induced ST muscle fatigue. EMG activities of the muscles around the knee joint were altered during the landing task after ST muscle fatigue.

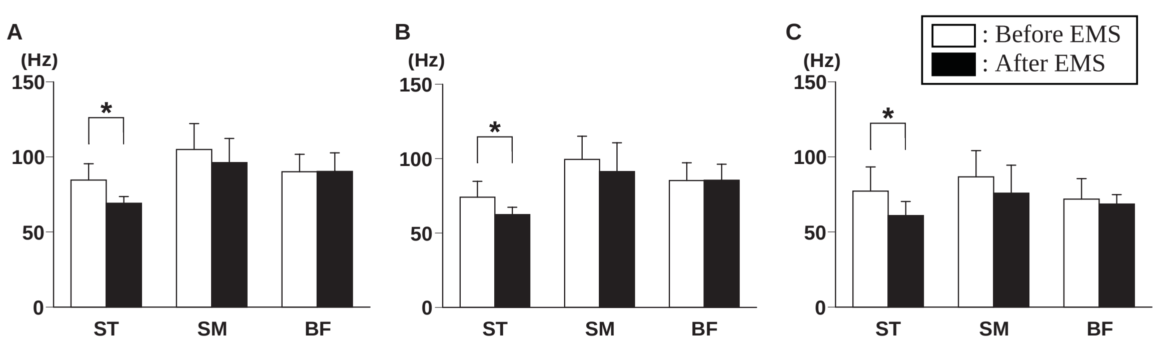

Figure 1: The median power frequency values for the semitendinosus (ST), semimenbranosus (SM), and biceps femoris (BF) muscles in experiment 1. Only the values for the ST muscle show significant alteration after electrical muscle stimulation. (A: 25% maximum voluntary isometric contraction (MVC); B: 50% MVC; C: 75% MVC)

THE EFFECT OF JUMPING ON SENSORIMOTOR PERFORMANCE

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AIM: The study evaluates the effect of jumping on sensorimotor parameters of visually-guided COM tracking task, postural stability and explosive power of lower limbs.
METHODS: Subjects (6 aerobic gymnasts of age 15.0 ± 2.5 y, height 157.8 ± 5.1 cm, and weight 49.6 ± 6.5 kg) were provided by feedback on COM displacement on a computer screen while standing on dynamometric platform. Their task was to trace, by shifting COM, a curve flowing either in horizontal or in vertical direction. The test consisting of 5 sets of 30-seconds (randomly performing in antero-posterior and medio-lateral direction) was interrupted by 60-seconds of jumping. The deviation of instant COP position from the curve was recorded at 100 Hz by means of the system FiTRO Sway Check. During serial jumps the power in the concentric phase of take off was registered using the PC based system FiTRO Jumper. Its calculation is based on contact and flight times measured by the contact mattress with an accuracy of 1 ms. Prior to the first and after the last set of jumps the force gradient in the time interval of 0-100 ms was determined during maximal isometric muscle contraction. Also postural stability under eyes open and eyes closed conditions was evaluated in order to calculate the Romberg quotient. The COP velocity was registered at 100 Hz by means of the posturography system FiTRO Sway Check based on dynamometric platform.
RESULTS: Results showed that after jumping (about 110 jumps in each set) mean COP distance from horizontally flowing curve significantly ($p \leq 0.05$) increased (from 12.2 ± 1.8 mm to 16.6 ± 2.4 mm), whereas only slight changes were observed in medio-lateral direction (from 11.1 ± 1.6 mm to 13.4 ± 2.0 mm). Also the COP velocity significantly ($p \leq 0.05$) increased under eyes closed condition (from 14.4 ± 2.3 mm/s to 19.2 ± 2.8 mm/s), but not while standing with eyes open (from 11.7 ± 1.9 mm/s to 12.5 ± 2.1 mm/s). However, only slightly lower power in the concentric phase of take off after jumping was found (in average 2.7 W/kg). Likewise, there were no pre-post jumping differences in the force gradient (in average 1.2 N/ms). Impairment of visual feedback control of body position after jumping may be attributed to the deterioration of the ability to precise perceive COM position through use the proprioceptors, as well as to the impairment of motor ability to accurate regulate its movement during visually-guided COM tracking task. Though it is not possible to separate sensory and motor part of this task, one may expect mainly impairment of proprioceptive acuity after rebound jumps. It is beacuse the same receptors share on weight transmission from one to other leg, namely during regulation of COM movement in medio-lateral direction (cutaneous and GTO receptors), and discrimination of ankle joint position, namely during regulation of COM movement in antero-posterior direction (muscle spindle and cutaneous receptors). An increase in the Romberg quotient after jumping (in average 0.3) would also support the hypothesis that mainly sensory inputs were impaired by muscle fatigue. However, it is also possible that motor functions were affected. This assumption may be corroborated by decrease in power in the concentric phase of take off from the first to the last series of jumps (about 9.2 %). No significant changes may be due to the fact that the conditions of muscle work in the test were similar to the predominant dancing elements of aerobics.
CONCLUSION: Taking into account impairment of visual feedback control of body position and static balance under eyes closed and no significant changes in power output, it may be concluded that intensive jumping more profoundly affects sensory than motor functions.

ISOKINETIC KNEE MUSCLE STRENGTH IN 10-YEAR-OLD CHILDREN WITH GENERALIZED JOINT HYPERMOBILITY

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AIM: Knee muscle strength is reported to be reduced in children with Benign Joint Hypermobility Syndrome (BJHS). No study has reported motor deficits in children with Generalized Joint Hypermobility (GJH). Thus, the aim was to study self-assessed physical fitness, general health and isokinetic knee muscle strength in children with GJH compared with Non-GJH (NGJH), all without knee pain.
METHODS: Totally, 19 GJH-children (ten girls and nine boys) with a Beighton score ≥5 and at least one hypermobile knee (mean age 10.1, SD 0.5) and 20 NGJH-children (nine girls and eleven boys) with a Beighton score <5 and no hypermobile knee (mean age 10.2, SD 0.4) were included. Physical fitness (rated on a 100 mm VAS scale) and general health were self-assessed, while maximum handgrip, isokinetic concentric and eccentric knee flexion and extension muscle strength at 60˚/sec were measured. Knee muscle strength balance was calculated as conventional and functional Hamstring/Quadriceps (H/Q) ratios.
RESULTS: Besides a higher general flexibility (7.2 vs. 4.5; p<0.0001), children with GJH reported higher aerobic fitness (6.9 vs. 5.7; p=0.04), and tended to be engaged more often in sports (95% vs. 75%; p=0.09) than children with NGJH. There was no difference in isokinetic knee muscle strength between GJH and NGJH. However, girls with GJH had significantly lower normalized eccentric knee extension muscle strength at Peak Torque at 50˚ (PT50) and Peak Torque (PT) than girls with NGJH (1.93 Nm/kg vs. 2.20 Nm/kg, p=0.003; 2.36 Nm/kg vs. 2.69 Nm/kg, p=0.039). Girls compared to boys in general had lower conventional and functional concentric H/Q-ratios at PT50 and PT.
CONCLUSION: Children with GJH did not have lower self-assessed physical fitness and measured isokinetic knee muscle strength than NGJH. However, girls with GJH had reduced eccentric knee extension muscle strength, and generally girls had lower knee muscle strength balance (H/Q-ratios) than boys. The clinical implication of this is, that girls with GJH and girls in general, may be in risk for knee injuries. Future studies should focus on injury prevention for this group, and on the risk for development of BJHS and osteoarthritis due to GJH.
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DECOMPOSITION OF HDEMG INTO THE CONSTITUENT ACTION POTENTIAL TRAINS

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AIM: Decomposition of high-density surface EMG (HDsEMG) into the constituent action potential trains enables non-invasive tracking of anatomic properties and discharge characteristics of individual motor units (MU). However, due to the low selectivity of surface electrodes and the filtering effect of subcutaneous tissue, it has mainly been applied to low contraction levels in isometric conditions, with the number of identified MUs limited to a few tens out of several hundreds MUs active in the investigated muscle. The amount of information that can be extracted from decomposed HDsEMG and its representativeness for a whole muscle is still poorly understood as limitations of surface EMG decomposition are still under active research. This work will describe the state-of-the-art in the decomposition of HDEMG, with particular focus on:

a) Decomposition of HDEMG acquired at high contraction levels;
b) Validation of HDsEMG decomposition and extraction of information from simultaneously recorded intramuscular and surface EMG;
c) Comparison between information extracted from commonly used global metrics of surface EMG (RMS, ARV, MDF etc.) and information extracted from individual MUs.
d) Quantification of the detection volume of HDEMG in which we can expect accurate identification of discharge patterns of individual MUs and representativeness of identified MUs for the whole muscle.

METHODS AND RESULTS: Decomposition of HDEMG will be demonstrated on EMG signals recorded by various two-dimensional arrays of surface electrodes from muscles of different sizes and anatomies, including fusiform (e.g., biceps brachii, abductor pollicis brevis), pennate (e.g., gastrocnemius, soleus) and annular muscles (e.g., external anal sphincter). Detection volume of HDEMG will be studied with the help of advanced surface EMG simulators and analysis of simultaneously recorded surface and intramuscular EMG in experimental conditions. The latter analysis will also be employed for validation of experimental HDEMG decomposition. Results of individual motor unit analysis will be compared to the results of global EMG metrics, such as various amplitude estimators (RMS, ARV), power spectrum estimators (MNF, MDF) and other frequently used surface EMG metrics. The limitations of advanced EMG decompositions techniques will also be demonstrated and thoroughly discussed.

CONCLUSION: Decomposition of HDEMG is very active research field and still under careful experimental validation. Although many questions remain open for future work, preliminary results on several hundreds of subjects and muscles with different anatomical properties have already shown very promising results and demonstrated the potential of surface electromyography as non-invasive tool for monitoring of individual MUs.

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DECOMPOSITION OF SURFACE EMG: DATA MODELS, ALGORITHMS AND LIMITATIONS

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AIM: Decomposition of surface EMG into contributions of individual motor units (MUs) differs significantly from decomposition of intramuscular EMG. When compared to intramuscular electrodes, surface electrodes are much less selective and detect contributions of several tens of simultaneously active MUs. In addition, subcutaneous tissue that separates the pick-up electrodes from the MUs acts a like low-pass filter, decreasing the bandwidth of acquired EMG signals and hindering the morphological differences among the detected motor unit potentials (MUPs). These constraints impose severe limitations to the surface EMG decomposition algorithms, which must, thus, rely extensively on the properties of the underlying data model to cope with high complexity of superimposed MUPs.

Many surface EMG decomposition algorithms have been proposed and their performance varies significantly over different experimental conditions. Although the choice of decomposition algorithm depends on many application-specific considerations, the selection of a good data model is often of primary concern. In this lecture, we will discuss and compare commonly used data models in surface electromyography and compare them to decomposition of intramuscular EMG. Methodological limitations of surface EMG decomposition in general and the potential of joint intramuscular and surface EMG recordings will also be discussed.

METHODS AND RESULTS: The first part of the lecture will offer an overview of the state-of-the-art in decomposition of surface EMG. Both families of decomposition algorithms, i.e, template matching and blind source separation, will be mutually compared from the viewpoint of selected data model, performance and the experimental setup. Template matching algorithms typically rely on a small number of acquired EMG channels and on a large set of priors on MU discharge patterns. Blind source separation, on the other hand, builds on strict mathematical models of the EMG mixing process, imposes fewer limitations to MU discharge patterns but requires a large number of EMG channels.

In the second part of the lecture, detection volume of surface EMG will be quantified in both simulated and experimental conditions, with focus on extraction of individual MU properties. The need for a large number of channels will be thoroughly examined. Finally, the amount of information extracted from simultaneously acquired intramuscular and surface EMG will be quantified and the benefits of joint intramuscular and surface EMG acquisition discussed.

CONCLUSION: Decomposition of surface EMG enables non-invasive monitoring of individual MUs and provides many important applications. However, it has many limitations that must be understood and considered when planning experimental or clinical examinations.

ACKNOWLEDGEMENT: This work was supported by a Marie Curie Reintegration Grant iMOVE (Contract No. 239216) within the 7th European Community Framework Programme and by Slovenian Research Agency (P2-0041).

GRADIENT-BASED DECOMPOSITON OF SURFACE ELECTROMYOGRAMS

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AIM: In (1), gradient Convolution Kernel Compensation (gCKC) technique was proposed for direct assessment of motor unit (MU) discharge patterns from high-density surface electromyograms (HDsEMG). This method employs gradient-based optimization of MU discharge patterns and is not sensitive to superimpositions of MU potentials. In this study, we analyzed and mutually compared different cost functions for the gCKC optimization algorithm and outlined their impact on convergence and stability of gCKC technique.
METHODS: Various cost functions (Kurtosis, Gaussian, Logistic, Huber, Geman and Welsh function) for Independent Component Analysis (ICA) of both noiseless and noisy mixtures were tested (see (3) for details on cost functions). Analytical model of mixing process of MU discharge patterns has also been developed and non-convex function $t_i \cdot log(1+t_i^2)-2 \cdot t_i + 2 \cdot atan(t_i)$, with t_i denoting the current estimate of the *i*-th MU discharge pattern, proposed as a model specific cost function. The convergence and stability of gCKC was tested on multichannel synthetic and experimental sEMG. EMG simulation modalities were similar to those described in (2). Two different levels of constant excitation to the muscle were tested: 10% and 30% of Maximum Voluntary Contraction (MVC). The number of MUs active at 10% (30%) MVC was 63 (93) out of 120 simulated. Coloured Gaussian noise was added to 10 s long synthetic signals, with SNR ranging from 0 dB to 20 dB. Ten simulation runs were performed per each contraction level and each SNR. Experimental HDsEMG was acquired in ten healthy young subjects from the Abductor Pollicis Brevis (ABP) and External Annal Sphicter (EAS) muscle during their isometric, 10 s long constant force contractions at 10 % of MVC (APB) and 100 % of MVC (EAS).
RESULTS: In synthetic sEMG with 15 dB noise and contraction level of 10% (30%) MVC, the model specific cost function identified 14 ± 3 (9 ± 2) MUs with ≥ 90 % of discharges identified within 1 ms from their simulated reference values. For Logistic cost function, these figures decreased to 5 ± 2 (3 ± 2) MUs. Other cost functions failed to converge, mainly due to their sensitivity to noise outliers or modelling errors. In experimental sEMG from ABP (EAS) muscle, the model specific cost function identified 18 ± 4 (7 ± 3) MUs, Logistic cost function identified 4 ± 2 (1 ± 2) MUs whereas other cost functions failed to converge.
CONCLUSION: The model specific cost function significantly outperformed classical ICA cost functions, especially in presence of severe noise and in experimental conditions, where the quality of acquired HDsEMG signals cannot be strictly controlled.
ACKNOWLEDGEMENT: This work was supported by a Marie Curie Reintegration grant within the 7th European Community Framework Programme (iMOVE, Contract No. 239216) and by Slovenian Research Agency (P2-0041).
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WALKING AT IMPOSED CADENCE SHOWS LOWER LIMB EMG AND KINEMATIC ALTERATIONS IN DIABETIC NEUROPATHIC INDIVIDUALS

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AIM: Increasing disturbance in the motor control system of diabetic neuropathic (DN) individuals with a higher demand for strength and propulsion during gait through increasing in cadence may reveal more complex motor adjustments to compensate the effects of this disturbance and deficits from the disease. This study investigated the effect of DN and cadence in lower extremity EMG and kinematics during the whole gait cycle.
METHODS: 23 non-diabetics (CG) and 23 DN walked at two cadences (self-selected and imposed cadence: 25% higher than self-selected). EMG of vastus lateralis, gastrocnemius medialis (GM), peroneus longus and tibialis anterior (TA) were assessed, as well as hip, knee and ankle angular variation during stance and swing phases. The variables were compared between groups and cadences in both phases using ANOVAs 2-way for repeated measures.
RESULTS: The diabetic individuals presented a delay in GM activity in both phases (table 1), irrespective of cadence and they did not anticipate TA activity during imposed cadence as the controls performed. During the imposed cadence, diabetic individuals had a reduced ankle ROM compared to the self-selected cadence in stance phase, while non-diabetic individuals had an increased ankle ROM (table 2). Diabetic individuals also showed reduced knee ROM during the imposed cadence in stance phase, and it was even greater during the swing phase (table 2).
CONCLUSION: The association of sensorial and motor deficits due to the DN and the increase of cadence in gait had substantially influenced the ankle and knee kinematics and TA and GM muscle activity during the gait cycle.

Table 1. Mean (±1 standard deviation) of time of peak occurrence (0 a 100% of phase) of GM of CG and DN, during the stance and swing phases in both cadences.

		Stance phase		P-values			Swing phase		P-values		
Time peak occurrence (%)	**Cadence**	**CG (n=23)**	**DN (n=23)**	**Group**	**Cadence**	**Group x Cadence**	**CG (n=23)**	**DN (n=23)**	**Group**	**Cadence**	**Group x Cadence**
Gastrocnemius medialis	Self-selected	54.33 (6.18)§	60.16 (6.99)§	**0.001**§	0.477	0.889	58.90 (10.09)§	62.24 (10.44)§	**0.005**§	0.086	**0.048**#
	Imposed	53.57 (6.80)§	59.65 (4.64)§				59.62 (16.14)§	75.40 (15.57)§#			

§ represents statistically differences between groups (CG x DN); * represents statistically differences between cadences in each group (self-selected cadence x imposed cadence); # represents groups and cadences interaction (CG x DN x self-selected cadence x imposed cadence)

Table 2. Mean (±1 standard deviation) of range of motion (ROM) knee and ankle joints of CG and DN, during the stance and swing phases in both cadences.

	Stance Phase		P- values			Swing Phase		P- values		
	CG (n= 23)	**DN (n= 23)**	**Group**	**Cadence**	**Group x Cadence**	**CG (n= 23)**	**DN (n= 23)**	**Group**	**Cadence**	**Group x Cadence**
Knee ROM (degrees)										
Self-selected cadence	28,66 (3.32) §	25,22 (4,21) §	**0.008**§	0.543	0.219	61.33 (3.88)	58.29 (4.15)*	**0.005**§	**0.032***	0.413
Imposed cadence	27,57 (4,42) §	25,6 (3,37) §				60.48 (5.15)§	56.44 (4.98)§ *			
Ankle ROM (degrees)										
Self-selected cadence	17,13 (2.54)	17.74 (2,65)	0.401	0.786	**0.002**#	16.59(3.93)§ *	11.07 (2.99)§ *	**<0.001**§	**<0.001***	0.163
Imposed cadence	18.2 (2,89)	16.47 (2.02)#				19.10 (4.01)§ *	12.56 (2.70)§ *			

§ represents statistically differences between groups (CG x DN); * represents statistically differences between cadences in each group (self-selected cadence x imposed cadence); # represents groups and cadences interaction (CG x DN x self-selected cadence x imposed cadence)

ANTAGONIST EFFECT ON THE TORQUE-ANGLE RELATIONSHIP IN MAXIMAL PLANTAR- AND DORSI-FLEXION

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AIM: The aim of this study was to determine the mechanical contribution of the plantar- and dorsi-flexors acting as antagonist at five different angles at the ankle joint. We hypothesize that the antagonist torque could influence the shape of the torque-angle relationship in the both maximal effort in plantar- (PF) and dorsi-flexion (DF).
METHODS: Twelve young subjects (mean: 26.8 ± 2.9 years old) volunteered to participate in this study. Maximal voluntary contractions (MVCs) in DF and PF were measured in isometric condition with the ankle joint at -20° and -10° DF, 0° (correspond to the neutral position, the footplate of the dynamometer perpendicular to the tibia), +10° and +20° PF. The electromyographic (EMG) activity was recorded for the tibialis anterior (TA) and the triceps surae (TS) muscles. The antagonist torque was estimated via an EMG biofeedback method (Billot et al. 2009).
RESULTS: During the PF MVC, our results showed that TA antagonist torque was not significantly different with ankle angle and had a negligible impact on the torque-angle relationship. At the opposite, during the DF MVC, the TS antagonist torque was significantly altered by the ankle joint angle and it significantly influenced the shape of the torque-angle relationship.
CONCLUSION: While the TA antagonist torque appears to be negligible during PF MVC whatever the ankle angle, the TS acting as antagonist plays a significant role during DF MVC according to the ankle angle. Finally, we concluded that, when investigating the impact of the ankle joint angle on the dorsiflexors' strength, the choice to consider the resultant torque instead of the agonist one will conduct to different findings.

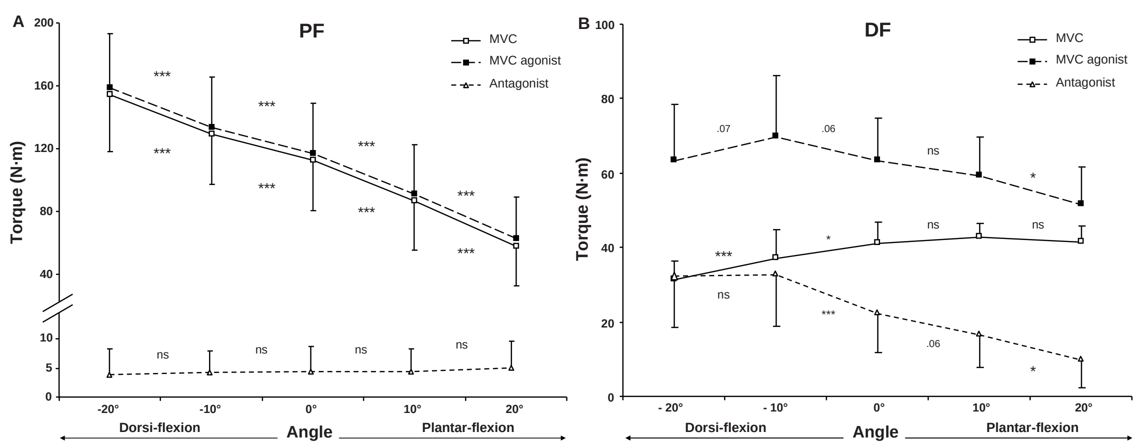

Figure 1. Resultant, agonist and antagonist torques developed during PF (A) and DF (B) MVC. Significant difference between consecutive angles, * $p < 0.05$ and *** $p < 0.001$. No significant difference (ns), $p > 0.05$.

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SPINAL REFLEXES: A POSSIBLE MARKER FOR WALKING ABILITY AFTER INCOMPLETE SPINAL CORD INJURY

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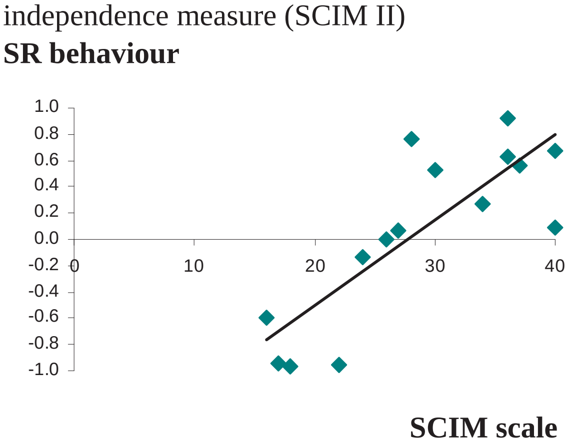
AIM: Spinal reflexes (SR) are a common tool to investigate changes in spinal neuronal circuits after SCI. There are two known polysynaptic SR components in humans: an early (60-120ms latency) and a late (120-450ms latency) SR component. So far, polysynaptic SR are suggested to provide a measure for the restoration of stepping ability after SCI in rats. Correspondingly, the presence of an early SR component is associated with a preserved locomotor activity in subjects with ambulatory incomplete SCI. The aim of this study was to investigate the connection of spinal reflexes (SR) and the preserved walking ability in chronic incomplete spinal cord injury (SCI).
METHOD: SR and walking ability were assessed in 15 chronic (lesion duration > one year) incomplete para-/tetraplegic SCI subjects. SR were evoked by tibial nerve stimulation and electromyographic analyses were done in four leg muscles of both legs. Walking ability of SCI subjects was assessed by three different functional tests / questionnaires.
RESULTS: There was a significant correlation of walking ability and SR behaviour in chronic incomplete SCI: severely affected SCI subjects with low to no walking ability showed dominating late SR components, whereas less affected ambulatory SCI subjects showed early SR components (as example see Fig.1).
CONCLUSION: The early SR component might be useful as a marker for preserved locomotor activity in incomplete SCI. On the other hand it will be important to analyse if new locomotor training methods will be associated with a persistence of the early SR component and a functional improvement in locomotion.
ACKNOWLEDGEMENT: This work was supported by the European Commission by the seventh framework programme through the 'Spinal Cord Repair' (HEALTH-F2-2007-201 144) and the Swiss National Science Foundation (NF32-117768/7).

Figure 1: Correlation between SR behaviour and the mobility part of the spinal cord independence measure (SCIM II)



SR behaviour on x-axis:
> 0 = early SR dominant (60-120ms latency)
0 = equal early and late SR component
< 0 = late SR dominant (120-450ms latency)

SCIM scale on y-axis
0 = totally dependent in daily mobility
40 = full independency in daily mobility

r = 0.82
p < 0.05

IS BALANCE WORSE WHEN STANDING AT HEIGHT? MUSCLE ACTIVITY DURING ONE-LEGGED STANCE UNDER POSTURAL THREAT

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AIM: It is known that gait changes occur when people walk at height: an increase in double support phase and stride time, a decrease in velocity and stride length have been reported. It is not established whether these changes reflect perception of the drop only, or whether control of balance is actually worse under these conditions. If balance ability at height is intrinsically reduced, changes in gait or posture would be better explained. Our aim is to investigate whether there is evidence from muscle activity to support the hypothesis that balance is worse when standing at height / under postural threat.
METHODS: Ten healthy subjects performed a series of walking and one-legged stance tasks on the ground and at 3.06 m off the ground (presented in random order to the subjects). Here we report the one-legged stance task at four different locations. Subjects performed a one-legged balance test (i) on the area in front of a 22 cm wide walkway (edge), (ii) on the walkway at ground level (walkway height 4.3 cm), (iii) at a platform in front of a 22 cm wide walkway and (iv) on the walkway 3.06 m elevated off the floor. For these tasks the postural threat differs, in ascending order: edge at ground level, walkway at ground level (constraint of width), edge at height and walkway at height (constraint of width and more exposed). At height the platform was shielded with curtains on three sides to ensure subjects did not see the height before the experiments started also subjects were not allowed to test the safety system. Electromyography (EMG) was recorded from the Tibialis Anterior (TA), Gastrocnemius (GAS), Soleus (SOL), Rectus Femoris (RF), Vastus Lateralis (VL) and Hamstring (HAM) using Trigno™ wireless system (Delsys, Inc). Galvanic skin conductance was recorded continuously during the experiment. Baseline measures were taken lying down and during normal standing prior to the start of the experiment.
RESULTS: Regarding muscle activity, preliminary results show that the two tasks at the ground level did not differ from each other while the two tasks at height did. TA, GAS and RF muscles showed a significant increase in activity on the walkway (more exposed area) compared to the edge. Furthermore, the one-legged stance task at the edge (just in front of the walkways) differed between the ground and height level; there was an increase in activity for the VL muscle. All muscles showed a significant increase in activity in the one-legged stance task on the walkway at height compared to the task at ground level.
CONCLUSION: There is an increase in muscle activity for a one-legged stance task with an increase in postural threat. Judging balance with muscle activity as parameter suggests that balance ability is reduced at height, since more muscle activity is used to do the same task. An obvious explanation for reduced balance at height is the altered visual information. However, in a previous study we showed that removing visual information of the drop during walking at height did not change the gait adaptation made when walking at height (Tersteeg et al., submitted). This indicates that knowledge of the drop, and the resulting motor set, is the strongest factor driving changes in balance and locomotion. Thus, response to knowledge of the drop alters and interferes with normal control of balance.

GAIT PATTERN IN 10 YEAR OLD CHILDREN WITH GENERALIZED JOINT HYPERMOBILITY

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AIM: To study whether the gait pattern in 10-year old children with GJH is different from the gait pattern of 10-year old children without GJH (controls) by measuring joint moments, joint angles of ankle, knee and hip joints as well as the ground reaction forces (GRF) during the stance phase.
METHODS: Inclusion criteria for GJH children (n=10 girls and 9 boys) were a Beighton score ≥5, at least one hypermobile knee joint, and for controls (n=8 girls and 10 boys) a Beighton score <5, and for both groups no knee pain during the last week. A total of 37 children, (mean 10.1 years) from a previous cohort study, were analyzed in 3D in a clinical gait lab at a walking velocity of 1,22 m/s (SD 0,04). Thirty different variables, including joint angles (sagittal plane), moments (sagittal and frontal planes) and GRF (vertical and anterior-posterior directions) for the hip, knee and ankle were measured.
RESULTS: Overall there were only few significant differences between the groups. Children with GJH demonstrated a smaller second peak knee abductor moment, (fK2) (figure 1A) than controls (p=0,043). No significant differences were found between GJH girls and control girls. The boys with GJH walked with a smaller second peak hip abductor moment (fH2) (figure 1B) than control boys (p=0,016).
CONCLUSION: There was only two gait pattern parameters that appeared to differ significantly between children with GJH and controls of which one only differ between GJH boys and control boys. Thus, the gait pattern in 10-year-old children with GJH, without knee pain and a Beighton score ≥5, is not different from the gait pattern observed in the control children.

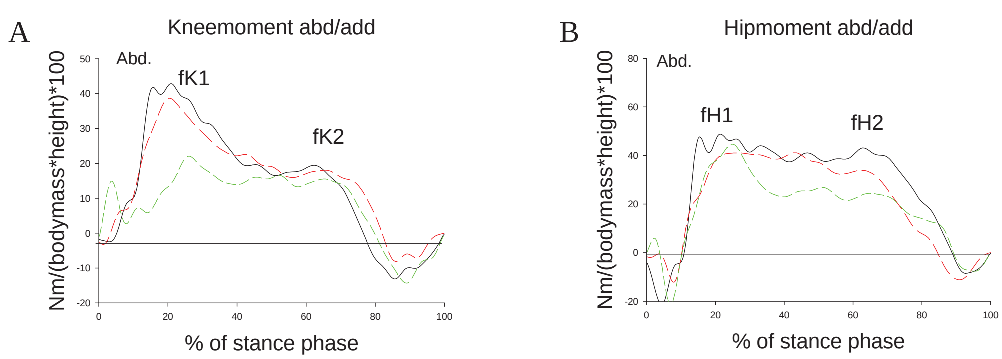

Figure 1: Showing some of the peaks used for calculation, illustrated by three trials of one child. A: Frontal plane knee moment peaks (fK1, fK2). B: Frontal plane hip moment peaks (fK1, FK2).

INFLUENCE OF DIFFERENT MUSCLE PERCUTANEOUS ELECTRICAL STIMULATION PROCEDURES ON THE EVOKED MUSCULAR ACTIVITY

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AIM: Aim of the study was to investigate the muscle evoked force and local oxygen consumption by applying two different electrical stimulation (ES) procedures: firstly, the main motor point was considered for cathode positioning and the stimulus amplitude was set to the level eliciting the maximal muscular response (Mmax) defined by electromyography (EMG) detection; secondly, the electrodes were positioned following standard reference charts for electrode placement and stimulus amplitude set according to subject tolerance.
METHODS: 10 subjects (28.4±8.2 yo) for tibialis anterior (TA) and 7 subjects (25.1±3.9 yo) for vastus lateralis (VL) were tested. The leg was fixed in an specifically designed dynamometer equipped with a load-cell to measure the isometric tension exerted by the muscle. The EMG and NIRS (Near InfraRed Spectroscopy) probes were placed on the muscle belly to detect the electrical and metabolic activity of the stimulated muscle, respectively. Two trials, corresponding to the different ES procedures, were performed for each muscle: 1. Cathode electrode placed on the main MP previously identified, by slowly moving a pen-electrode on the muscle surface, while the stimulation current was slowly increased by the operator until a minimal detectable mechanical response could be observed. Stimulation amplitude was then increased until the Mmax myoelectrical response was reached; 2. Cathode electrode was placed according to the common electrode positioning charts available on the market and stimulation amplitude set as the higher level tolerated by the subject. For both 1 and 2 procedures the anode electrode was kept as suggested by the standard charts and the stimulation protocol consisted of a frequency ramp with stimulation rate linearly increasing from 2 to 50 Hz in 7.5 s.
The parameters included in the analysis were the peak twitch (pT) at 2 Hz, the area under the force build-up (AFRC) to estimate the work performed by the contracting motor units, and the area below the oxygenated hemoglobin decrement dynamics (AOHb) reflecting the local muscle oxygen uptake, during the administered ramp.
RESULTS: Results are summarized in Table 1. For each parameter there was a significant reduction in Trial 2 with respect to Trial 1.
CONCLUSION: When percutaneous muscular stimulation is aimed to recover, maintain or enhance muscle trophism and performance, the level of the evoked activity should be sufficiently higher to elicit a training effect. On these basis, our results should be accounted for to reach the above mentioned outcomes since the muscle mechanical work and local metabolic expenditure (i.e. oxygen consumption) we investigated in the study are strongly dependent on a correct stimulation procedure.

Table 1: Parameters obtained in the two investigated procedures for TA and VL muscles.

	Tibialis Anterior			Vastus Lateralis		
	pT (N)	**AFRC** (N•s)	**AOHb** (μm•s)	**pT** (N)	**AFRC** (N•s)	**AOHb** (μm•s)
Trial 1	*4.55±2.86*	*397.3 ±282.7*	*65.9±36.9*	*6.73±3.96*	*1049.6±581.9*	*46.6±36.4*
Trial 2	*3.22±1.86*	*257.1 ±168.8*	*48±26.4*	*4.81±4.01*	*577.9 ±436.6*	*28.4±19.21*

MUSCLE RESPONSE EVOKED DURING PROLONGED STIMULATION TACTILE (VOJTA THERAPY)

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AIM: The aim of this study was to acknowledge a muscle responses associated to a tactile proprioceptive stimulation by pressing a thoracic point based on the principles of Vojta therapy.
METHODS: Eight healthy subjects were assessed, that didn't know about Vojta therapy before. They were positioned in supine position to be submitted to 5 tactile stimulations in the midline of the fifth intercostal space (5 min of stimulation and 5 min of comfortable rest between tests). During stimulation, physiological parameters were recorded: heart rate, respiratory rate and oxygen saturation. Fourteen muscle were recorded with surface EMG: right *Sternocleidomastoideus*, *Deltoideus anterior* right, *Deltoideus medialis* left, *Abductor digiti minimi* left, *Biceps brachii*, *Obliquuous externus abdominis*, *Rectus femoris*, *Semitendinosus, tibialis anterior* (Delsys ©). All surface EMG records were normalized to the value of the isometric maximal voluntary contraction (iCVM). In addition, the kinematic response was recorded with a motion capture system (Motion Analisys Corp.)
RESULTS: All assessed subjects presented a low-amplitude muscle response (3 to 5 % of iCVM). But none of them had the same order of recruitment, neither response in all muscle groups or in all tests. Despite the generated muscle responses maintained over time, only 1 subject responded with movement in his right foot with only 4 ° of movement. The rest didn´t present movement response but there was a low intensity muscle activity.
CONCLUSION: There are relationships between muscle responses of the subjects with stimulation. But there wasn´t a clear order of muscle recruitment or muscle onset pattern or amplitude of muscle response despite all subjects responded with greater or lesser intensity to stimulation.

HUMAN MUSCLE-TENDON UNIT FREQUENCY RESPONSE WITH DIFFERENT TENDON TRANSMITTING PROPERTIES

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AIM: Aim of the study was to investigate the intrinsic biomechanical properties of the *in vivo* human Tibialis Anterior (TA) muscle-tendon complex by means of a noninvasive procedure. The method is based on the quantification of the muscle-tendon unit transfer function in two conditions in which the tendon acts as a rigid or not tension transmitter.
METHODS: The leg of 8 healthy subjects (29±7.5 yo) was fixed in an isometric dynamometer equipped with a load-cell to measure the evoked TA muscle tension. The amplitude of a 40 Hz stimulation train administered at the TA motor point was varied sinusoidally, thus changing the number of the recruited motor units and hence the tension at the tendon in the same fashion. The muscle was stimulated with a sequence of different sinusoidal frequencies (0.4, 1.0, 1.8, 2.5, 3.0, 4.5, 6.0 Hz; total duration of ~12 s) in two different experimental conditions: a) the amplitude range evoked tension always higher than 20% of the maximal tetanic torque output, measured during a supramaximal (full motor units recruitment) 40 Hz tetanus, thus with the tendon behaving as a rigid transmitter (as reported in literature); b) the sinusoidal torque output never trespassed the 20% of maximal tetanic contraction, thus with the tendon not acting as a rigid transmitter.
For both protocols the Bode plots for average (mean±SD) gain attenuation and phase shift at each modulating frequency, reporting the amplitude reduction and phase shift with respect to the input sine, were calculated.
RESULTS: In both protocols, from the Bode plots it was possible to model the force dynamic response of the TA muscle-tendon unit by a critically damped II order system with two coincident poles + a pure time delay:
a) stiff system: poles at 2.63 Hz and pure time delay of 16.3 ms.
b) slack system: poles at 2.04 Hz and pure time delay of 13.0 ms.
The poles position mean value retrieved in b) was significantly lower than in a) suggesting that the model retrieved from the latter condition data may describe the dynamic response of a slower system.
CONCLUSION: The method, based on in vivo quantification of the muscle-tendon unit frequency response, represent a novel and noninvasive method to test the influence of the muscle model elastic components on the transfer function of the system. This achievement may be a tool to study and monitor the properties of muscle-tendon mechanics particularly in sports medicine and rehabilitation.

POSTURE AND HAND LOAD ALTER MUSCULAR RESPONSE TO SUDDEN PERTURBATIONS

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AIM: This study investigated the effects of arm posture and hand load on upper extremity muscle activity when perturbations were applied to the wrist. Muscle activities were examined pre and post perturbation to examine the response to sudden loading.
METHODS: Fifteen right handed males participated (26.4 ± 2.9 yr; 1.80 ± 0.07 m; 82.3 ± 8.3 kg). A splint maintained neutral wrist posture while participants were positioned in three body postures all with the elbow flexed to 90°: i. lying supine on a table, ii. standing, and iii. sitting (shoulder flexed to 90°, upper arm on table). A pneumatic arm instrumented with a load cell was oriented to deliver a push force to the palmar side of the wrist causing elbow extension. The hand was subjected to 3 conditions: no load, holding a tube horizontally ("solid") and balancing a water filled tube ("fluid"). Each tube was 0.68 kg, 34.5 cm long and 2.54 cm in diameter. Perturbation timing was known or unknown to the participant depending on the trial. Three trials were performed for each combination of posture, load and timing knowledge. Eight muscles on the right upper extremity were monitored using surface EMG (Bortec Biomedical Ltd., AB, Canada). Muscles included anterior deltoid (AD), triceps brachii (TB), biceps brachii (BB), brachioradialis (BR), flexor carpi radialis (FCR), flexor digitorum superficialis (FDS), extensor carpi radialis (ECR) and extensor digitorum (ED). EMG and force were sampled at 2048 Hz. EMG signals were linear enveloped at 3 Hz and normalized to muscle specific maximal voluntary excitation (MVE). Two time periods were analyzed, baseline (150 - 100 ms pre-perturbation) and reflex (25 - 150 ms post-perturbation). A repeated measures ANOVA was performed to determine the effects of posture, hand load and perturbation knowledge on muscle activity.
RESULTS: The mean push force was 61.7 ± 16.5 N and 12.7 ± 3.8 N at baseline (all conditions). Time period had a significant effect on all muscles as reflex activity was greater than baseline ($p<0.05$). A significant main effect of posture was found for all muscles except TB during both baseline and reflex periods. The forearm extensors baseline and reflex activity were greater during sitting than standing. For FCR, FDS, BR and BB, standing resulted in greater activity than both sitting and supine postures. FCR and FDS activity were 2.3% and 1.7% MVE greater while standing than sitting and over 3% MVE greater in supine versus sitting. The type of hand load significantly affected all muscles except TB. During the reflex period, the fluid tube had the greatest response, with activity for each muscle differing significantly for all loads. At baseline, only extensor muscle activity differed significantly with hand condition; the fluid tube required 38.9% (ECR) and 50.3% (ED) greater activity than the solid tube. For ED, the load types resulted in AEMG of 2.7%, 6.0% and 9.0% MVE for no load, solid, and fluid conditions, respectively.
CONCLUSION: The increase in muscle activity immediately following the perturbation confirms the significance of reflex action as a preliminary response to unexpected loading. Greater forearm extensor baseline activity with either hand load suggests increased co-contraction prior to the perturbation. This response is necessary to balance moments at the wrist but likely has consequences for elbow stability. A biomechanical model to estimate muscle forces and joint rotational stiffness (Potvin and Brown, 2005) is underway to better understand muscle contributions to elbow stability.
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RECRUITMENT OF TRANSVERSUS ABDOMINIS AND LUMBAR MULTIFIDUS DURING A NEW MODE OF EXERCISE

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AIM: A new exercise device has recently been developed with an aim to specifically target recruitment of key local muscles of the trunk. These muscles are well known to be dysfunctional in the low back pain population. The new exercise device allows the user to move their legs in a cyclical motion under minimal external resistance whilst supporting themselves against gravity, either sitting or standing. The aim of this study was to determine the differences in recruitment of two key local muscles of the trunk when sitting and standing on the device in both rest and exercise conditions.
METHODS: Twelve asymptomatic participants (6 female, age 21-41 years) consented to take part in the study, which obtained institutional ethical approval. The thickness of the left Transversus Abdominis (TrA) and Lumbar Multifidus (LM) were measured with an ultrasound imaging system (Sonosite) using a 2-5 MHz convex transducer. For the TrA, the transducer was held transversely and positioned antero-laterally, mid way between the superior iliac spine and the inferior eighth rib. For the LM, the transducer was held longitudinally and positioned over the L4/5 facet joint. The thickness of the Lumbar Multifidus was measured from the superficial border of the L4/5 facet joint and the superficial fascia of the muscle, just below the subcutaneous layer. The thickness of both muscles, whilst either sitting or standing on the device at both rest and exercise, was determined using the calipers within the imaging software. A 2 (sit/stand) x 2 (rest/exercise) ANOVA with repeated measures, post hoc Tukey, was used to determine the significance of any differences between conditions for each muscle. A 95% confidence level was used throughout.
RESULTS: Significant main effects were found on both factors for TrA (sit/stand: $F_{1,11} = 14.628$, $p<0.01$; rest/exercise: $F_{1,11} = 38.944$, $p<0.001$) and LM (sit/stand: $F_{1,11} = 75.039$, $p<0.001$; rest/exercise: $F_{1,11} = 25.006$, $p<0.001$). Post hoc analysis revealed significant increases in thickness between sitting and standing positions during rest for LM ($p<0.01$) and during exercise for both TrA ($p<0.05$) and LM ($p<0.01$). Significant increases were also seen between rest and exercise for TrA whilst sitting ($p<0.01$), and when standing for both TrA ($p<0.01$) and LM ($p<0.01$).
CONCLUSION: The data presented here demonstrate the increased effectiveness of the device in recruiting both the Transversus Abdominis and Lumbar Multifidus Muscles in an asymptomatic population whilst exercising in a standing position. During sitting, the only static point of contact with the device is the seat, as the feet are free to move. During standing, this static point of contact with the device is removed, thus increasing the instability of the movement, thus placing a greater demand on the local trunk musculature.

Table 1: TrA and LM thicknesses

	TrA (cm)	**LM (cm)**
Sitting at rest	0.43 (±0.13)	2.64 (±0.41)
Sitting exercise	0.54 (±0.15)	2.80 (±0.41)
Standing at rest	0.49 (±0.12)	3.05 (±0.35)
Standing exercise	0.63 (±0.13)	3.29 (±0.45)

TRANSVERSUS ABDOMINIS AND LUMBAR MULTIFIDUS RECRUITMENT DURING A RANGE OF STATIC POSTURES AND A VOLUNTARY CONTRACTION

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AIM: The aim of this study was to determine the level of recruitment of transversus Abdominis (TrA) and Lumbar Multifidus (LM), key local trunk muscles, in lying at rest, sitting, standing and during a voluntary contraction. Several previous studies demonstrated these muscles to be dysfunctional in people with low back pain.
METHODS: The thickness of TrA and LM were measured using a Sonosite ultrasound imaging system with a 2-5 MHz curvilinear transducer. Twelve non-symptomatic volunteers age 21-41 (6 male and 6 female) were recruited to the study which received institutional ethics approval. The thickness of both muscles in the different test conditions was measured using the calipers within the imaging software. Instructions given for the voluntary contractions of LM and TrA were consistent with those recommended by widely acknowledged international experts in the field. Photographs were taken of all volunteers in all positions. A one way ANOVA with repeated measures, post hoc Tukey, was used to determine the significance of any differences between conditions for each muscle. A 95% confidence level was used throughout.
RESULTS: Significant main effects were seen for both TrA ($F_{3,33} = 57.482$) and LM ($F_{3,33} = 9.618$). TrA thickness was found to be increased significantly during voluntary contraction compared to lying at rest ($p<0.01$), sitting ($p<0.01$) and standing ($p<0.05$). TrA thickness was also significantly increased from lying when sitting ($p<0.01$) and standing ($p<0.05$). No significant difference was seen in TrA thickness between sitting and standing. LM thickness did not change significantly from lying either during voluntary contraction or when sitting. However, a significant increase in LM thickness was seen in standing when compared to lying at rest ($p<0.01$), sitting ($p<0.01$) and during the voluntary contraction ($p<0.05$).
CONCLUSION: Individuals' difficulty to contract LM voluntarily is consistent with published literature. The significant increase in LM thickness we found in standing may be explained by the fact that LM provides 20% of extension torque in the lower lumbar spine. TrA is widely found to be easier to contract voluntarily than LM which may explain its 100% increase in thickness from lying/rest to voluntary contraction. The significant increase in LM thickness from lying to sitting may be explained by volunteers' posteriorly tilted pelvis in sitting (as evident from the photographs), and therefore, their need to work their TrA to achieve and maintain an upright trunk posture in this position.
The use of photographs is essential to allow interpretation of findings in context, and thickness changes in the other muscles of the abdominal wall need to be considered to inform instructions to subjects on contracting/recruiting TrA.

Table 1: TrA and LM thicknesses and percent changes

	TrA (cm)	% change from lying/rest	LM (cm)	% change from lying/rest
Lying/rest	0.38 (±0.06)	0	2.59 (±0.45)	0
Sitting	0.51 (±0.13)	34	2.66 (±0.42)	2.7
Standing	0.46 (±0.09)	21	2.99 (±0.30)	15
Voluntary contraction	0.76 (±0.16)	100	2.77 (±0.45)	7

CHANGES IN POSTURAL CONTROL STRATEGIES AGAINST AN EXTERNAL MECHANICAL DISTURBANCE IN SUBJECTS WITH EARLY STATES OF IDIOPATHIC PARKINSON'S DISEASE

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AIM: Parkinson's disease is characterized by alterations in postural control in final states of the disease. We hypothesize that postural alterations are initiated in early states. The aim of study was to analyze the effects on postural control response in subjects with early states of idiopathic Parkinson's disease under a mechanical disturbance and comparing the response with a control group.
METHODS: We assessed 10 subjects with early states of idiopathic Parkinson´s disease and ten control subjects. All subjects were submitted to an horizontal and posterior postural destabilization using a mobile force platform (AMTI©, with a displacement of 10 cm, acceleration and deceleration in ramp, with a velocity peak of 90 cm/s), in two conditions: eyes open and eyes close. The postural responses were recorded from left and right tibialis *anterior* (TA), *soleus*(SO), *rectus femoris* (RF), *biceps femoris* (BF), and *erector spinae*(ES) (Myomonitor IV. Delsys©). The muscle onset (base line more 5 standard deviations) were computed with a computational macro.
RESULTS: The preliminary results indicate differences on muscle response times in subjects with early stages Parkinson's disease in compared with control subjects.
CONCLUSION: The changes in postural responses are present in people with early stages idiopathic Parkinson´s disease, so the risk of falling is present from the beginning of this disease.

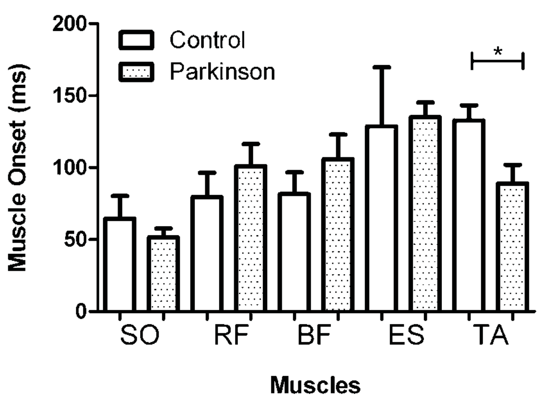

Figure 1: A example of muscular onset of subjects with early states idiopathic Parkinson´s disease and control subjects. Only tibialis anterior muscular onset were different (*p=0.026)

ELECTRICAL STIMULATION FOR TESTING THE NEUROMUSCULAR FUNCTION

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Neuromuscular function evaluation using electrical stimulation (ES) can contribute to our knowledge in how our body can adapt with age, training/detraining, fatigue, long-term spaceflight, environmental condition (hypoxia, hyperthermia), etc. This is also an interesting tool to evaluate the effect of a therapy/retraining program or the follow the history of a disease in patients. Skeletal muscle function can change in an acute or chronic way and this is due to central (neural) and/or peripheral (muscular) changes, which are somehow mutually dependent. To explore central modifications, the standard technique is the twitch interpolated method which consists in superimposing single twitches or high-frequency doublets to a maximal voluntary contractions (MVC) and to compare the superimposed response to the potentiated responses obtained on the relaxed muscle. Alternative methods consists in (i) superimposing a train of stimuli (central activation ratio), (ii) comparing the MVC response to the force evoked by a high-frequency tetanus or (iii) examining the change in maximal EMG response during voluntary contractions, provided this variable is normalized to maximal M-wave, *i.e.* EMG response to a single stimulus. A limit of these techniques is that they all request a MVC which may be problematic with patients or subjects not familiar with maximal contractions. Also, any of them allow to differentiate spinal to supraspinal mechanisms implicated in central adaptations since the all only reflect neural drive provided by the central nervous system to the muscle and not changes in the aptitude to generate output from the motor cortex. Supraspinal factors can however be investigated by using transcranial magnetic stimulation. Of note is the fact that ES is still requested since one variable recorded when using this technique (motor evoked potential) needs to be normalized by maximal M-wave. Supramaximal intensity, *i.e.* 120-150% of intensity that spatially recruits all motor units, is requested when studying fatigue because of the loss in axonal excitability. ES is also useful to investigate changes at the motoneurones level, either by using H reflexes or cervicomedullary motor-evoked potentials. Peripheral changes can also be investigated with ES, usually by stimulating the muscle in the relaxed state. Neuromuscular propagation of actions potentials on the sarcolemma (M-wave, high-frequency fatigue), excitation-contraction coupling (low-frequency fatigue, LFF), intrinsic force (high-frequency stimulation at supramaximal intensity) can be explored non-invasively with ES. However, as for all indirect methods, limits have to be acknowledged. For instance, the absence of modification of the low-to-high frequency ratio could result from the combined effects of LFF, which preferentially depresses low frequency response, and hyperpolarization, which preferentially depresses high frequency response.
More recently, the use of magnetic stimulation for peripheral and central measurements has been proposed, mostly for quadriceps assessment. The correspondence between electrical and magnetic stimulation has been ascertained but further limits exist with this latter technique, in particular for overweight subjects. Some stimuli are not well tolerated because of discomfort/pain, particularly nerve trunk stimulation of large muscle groups. As a consequence, adaptations of the stimulation protocols are mandatory with fragile people. For instance, it has been shown that LFF is comparable when evaluated with nerve and muscle stimulation and LFF could potentially be evaluated by using low- and high-frequency doublets.

THE EFFECTS OF A SINGLE SESSION OF WHOLE-BODY VIBRATION EXERCISE ON KNEE JOINT NEUROMUSCULAR FUNCTION AND POSITION SENSE

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AIM: Successful sports performance and the effective provision of dynamic joint stability may be dependent upon the capability for rapid initiation and generation of muscular force, as well as adequate proprioceptive capabilities. Whole-body vibration (WBV) is now a common warm-up and training modality. Knee joint neuromuscular function and proprioceptive acuity (e.g. joint position sense) following a single session of WBV have yet to be comprehensively evaluated. The aim of this investigation was to examine the acute effects of a WBV training session on electrically-evoked and voluntary neuromuscular function of the knee extensors, and knee joint position sense.
METHODS: Fourteen healthy males attended the laboratory on two separate occasions to complete two treatment conditions: (1) 5 x 1 minute of single-leg isometric squat (40° knee flexion) exercise on a vibrating platform (30 Hz, 4 mm peak-to-peak amplitude) (WBV); (2) a control condition (CON) of the same exercise without whole-body vibration. Knee joint position sense (magnitude and direction of joint re-positioning errors), electrically-evoked and voluntary neuromuscular function [maximal M-wave (M_{max}); electromechanical delay (EMD); peak force (PF); rate of force development (RFD); half-relaxation time (HRT); neural activation (EMG_{RMS}) normalised to M_{max}] of the knee extensors were assessed at 30° of knee flexion (0° = full extension) prior to, immediately after and 1 h after each treatment condition.
RESULTS: Repeated measures ANOVAs revealed no significant interaction (*condition x time*) or main effects (*condition; time*) for voluntary EMD; PF and associated EMG_{RMS}; RFD and EMG_{RMS} measured in 50, 100 and 150 ms time windows from onset of force and EMG (All, $P > 0.05$). The magnitude and direction of joint re-positioning errors remained unaffected by both treatment conditions ($P > 0.05$). Electrically-evoked EMD appeared to be improved to a greater extent immediately post-WBV (- 4%) versus CON (- 2%) ($F_{[2,26]} = 4.1$, $P = 0.030$). Similar enhancements in the speed of muscle contraction (RFD normalised to peak twitch force; $F_{[2,26]} = 13.5$, $P < 0.001$) and relaxation (HRT; $F_{[2,26]} = 11.7$, $P < 0.001$) were observed immediately following WBV (7 – 8%) and CON (8 – 9%) conditions.
CONCLUSION: A single session of WBV was not associated with changes to indices of voluntary neuromuscular function of the quadriceps. In particular, voluntary EMD remained unchanged despite a subtle WBV-related enhancement of electrically-evoked EMD. Additionally, concerns regarding the anticipation of acute negative effects of WBV on proprioceptive acuity at a 'vulnerable' joint angle were not supported by the data.
ACKNOWLEDGEMENTS: The authors would like to thank Power Plate® for the loan of the vibration platform.

THE SENLY PLATFORM: A NOVEL ROBOTIC MACHINE FOR FALL RISK ASSESSMENT AND PREVENTION

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AIM: The main goal of the SENLY platform is to allow the definition of successful programs for fall risk identification and prevention. It was demonstrated, in the literature, that subjects trained to react to simulated postural perturbation learn to react also to real life perturbations, reducing so their risk of fall (Pijnappels et al., 2008). A home made mechatronic platform was designed, by our group, with the main aim of simulating the highest possible number of fall provoking situations, while the subject is standing up or walking. The long term aim of our project is duplex: 1) to analyse the biomechanics of subject behavior in response to a wide number of possible perturbations; 2) to identify training protocols aimed to improve subjects ability to react to the imposed perturbations.
METHODS: The platform is mainly made by two treadmills, each acted by an electrical motor. Each treadmill is provided with an aluminum plane for supporting tester during walking, and each walking plane is supported by two tri-axial load cells and two mono-axial load cells. Furthermore treadmills are designed to be translated in the media lateral direction (300 mm of lateral translation). In order to obtain the required displacement, each treadmill is placed on two cylindrical rails passing laterally through the two treadmills. The treadmills are moved laterally through two racks each with its driving pinion. The belt slides on the walking plane generating on the tester a lateral perturbation on the foot/feet. The platform is provided with a structure where the tester, wearing a harness, is attached by means of a damper-cable-snap-hook system to avoid hits on the treadmill surface.
CONCLUSION: The SENLY platform will be able to generate perturbation in the horizontal plane both in standing and walking condition, and in the same time to measure vertical and tangential forces, for each foot acting on the platform. The technical specifications of the platform are the following: max walking speed: 1.8 m/s (~ 6.5 Km/h); max tester weight: 110 Kg; lateral acceleration: 2÷4 m/s^2; max lateral displacement: 300 mm; mean required time for perturbation: 0.5 s.
ACKNOWLEDGEMENT: Authors would like to thank Essegi Meccanica, S. Gimignano, Siena, Italy and Ing. Marco Presenti, for their contribution to this work.

Pijnappels M., Reeves ND., Maganaris CN., van Dieen JH., "Tripping without falling: lower limb strength, a limitation for balance recovery and a target for training in the elderly", *Journal of Electromyography and Kinesiology*, 18 (2008) 188-195

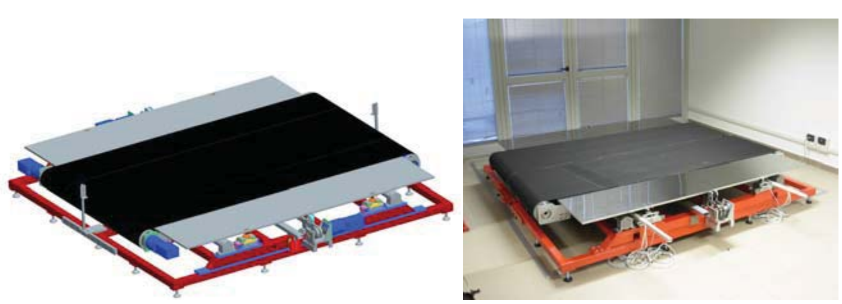

Figure 1: SENLY platform CAD model and platform first assembled prototype

ONE LEG BALANCE ~ 20 YEARS AFTER ACL RECONSTRUCTION

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AIM: Reconstruction after Anterior Cruciate Ligament (ACL)-injury does not fully restore knee function, and the long term consequences are not fully known. Muscle-weakness, reduced mechanical stability, impaired knee kinesthesia, osteoarthritis and kinesiofobia are factors that negatively influences motor control and performance. The aim of this follow up study was to examine probable deficits in the injured relative to the uninjured leg in One Leg Balance performance in subjects with ACL injury approximately 20 years post-injury.
METHODS: To date data has been collected from 20 subjects; 11 men and 9 women (46 ±5.6 years, BMI 26.3 ± 2.8) with unilateral ACL-injury acquired ~24 ±3.3 years ago and with reconstructive surgery ~3,8±2,9 years later. One Leg Balance was tested standing barefoot on a force platform (custom made, MTI, Umeå University, Sweden) with concurrent capture of 3-dimensional whole body kinematics (Oqus, Qualisys, Sweden) and EMG (MEGA, Finland), for 30 s. Tests were run with eyes open or closed and performed in a standard position with arms folded across the chest. Centre of pressure (CoP) was analyzed for sway path, mean and standard deviation of sway amplitude in anterior-posterior (AP) and medio-lateral (ML) directions. Leg Symmetry Index (LSI) was calculated. Time to first loss off balance and number of supports with contra lateral leg were recorded.
RESULTS: The mean amplitude of ML sway was larger for the injured leg in both conditions. Postural sway values were in general greater with eyes closed.
CONCLUSION: Overall the results suggest satisfactory function in the injured knee for this balance task. However, the differences in mean amplitude of ML sway needs attention. Structural analyses of CoP and additional kinematic and EMG analyses may elucidate postural control strategies for the ACL-injured leg. Additional comparisons to uninjured control subjects will be included. Effect of preferred leg will be considered.

Table 1: Posturographic measures in one leg balance. Means / SD.

Variable	Eyes open				Eyes closed				o/c
	Injured	**Uninjured**	***p***	**LSI %**	**Injured**	**Uninjured**	***p***	**LSI %**	***p***
Sway path (mm)	678/235	727/269	Ns	96/24	1458/625	1454/507	Ns	102/30	.000
Mean sway AP (mm)	22/6	23/6	Ns	98/21	27/6	29/10	Ns	98/22	.000
SD sway AP (mm)	4/1	4/1	Ns	97/22	8/3	8/3	Ns	113/63	.000
Mean sway ML (mm)	16/6	12/5	.019	167/116	17/5	13/5	.021	148/67	Ns
SD sway ML (mm)	4/1	3/1	Ns	108/33	6/3	7/4	Ns	90/30	.000
Time to failure (s)	29.1/3.8	27.9/4.8	Ns	109/32	12.2/11.0	9.0/9.4	Ns	391/643	.000
Supports (n)	0.2/0.7	0.2/0.6	Ns	——	2.7/2.2	2.7/2.1	Ns	——	.000

o/c: effect of open and closed eyes.
Leg Symmetry Index (LSI), %: LSI > 100% indicate that the performance of the injured leg is worse than that of the uninjured, i.e., greater postural sway. Sway LSI are based on all decimals, decimals in table are omitted.

RELIABILITY OF ELECTROMYOGRAPHY AND PEAK TORQUE DURING MAXIMUM VOLUNTARY CONCENTRIC, ISOMETRIC AND ECCENTRIC CONTRACTIONS OF QUADRICEPS MUSCLES IN HEALTHY SUBJECTS

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AIM: When it comes to evaluation, reliability plays an important role in the interpretation of research data. This matter is even more relevant in EMG if we consider the large number of factors that influence it. Consequently it seems wise to assume that only when we question the reliability of the data obtained can we safely assess its validity. To investigate the reliability of peak torque (PT) and of surface electromyography average full wave rectified signal (avgEMG) with and without electrode removal (1 week and 1 hour interval period, respectively) in 16 younger male sport students (age 21.0±1.2 yrs).
METHODS: Maximum voluntary dynamic (concentric 'CON' and eccentric 'ECC' at 60º/sec) and isometric ('ISO' at 60º of flexion during 5 sec) muscle contractions was assessed for the Vastus Lateralis (VL), Rectus Femoris (RF) and Vastus Medialis (VM) muscles. EMG analysis was performed through a window of 0,512 sec and of 2 sec, for dynamic and isometric contractions respectively, in the middle of the force curve. The intra-class correlation coefficient (ICC) was used to assess the data reliability.
RESULTS: The results show that all PT variables (CON, ECC and ISO) present excellent reliability. Moreover, all EMG variables present excellent reliability without electrode removal, except the RF muscle, that only present a good reliability.
With electrode removal, the EMG variables reliability decreases, with special focus in RF, which presents a poor reliability.
CONCLUSION: with this study we concluded that PT and EMG variables reliability is higher without electrode removal. Furthermore, the RF muscle seems to be less reliable that VL and VM muscles.

Table 1: Mean, Standard Deviation and ICC of PT (Nm) and avgEMG (mV) in VL, RF and VM muscles after 1 hour and 1 week interval periods.

			1 hour interval (without electrode removal)				1 week interval (with electrode removal)		
			test	retest	ICC		test	retest	ICC
MUSCLE STRENGHT ASSESSEMENT	CONCENTRIC	PT (Nm)	224.24 ± 28.23	221.82 ± 30.66	.98		224.24 ± 28.23	233.53 ± 31.19	.95
		avgVL (mV)	.763 ± .36	.636 ± .31	.97		.721 ± .27	.763 ± .36	.69
		avgRF (mV)	. 590 ± .20	.570 ± .21	.71		.642 ± .27	.590 ± .20	.82
		avgVM (mV)	.806 ± .33	.601 ± .26	.88		.824 ± .57	.806 ± .33	.80
	ISOMETRIC	PT (Nm)	237.84 ± 51.78	236.69 ± 57.91	.99		237.84 ± 51.78	244.93 ± 41.72	.90
		avgVL (mV)	.657 ± .42	.633 ± .33	.92		.485 ± .22	.633 ± .33	.76
		avgRF (mV)	.469 ± .21	.455 ± .18	.88		.436 ± .10	.455 ± .18	.50
		avgVM (mV)	.602 ± .27	.523 ± .22	.93		.541 ± .27	.523 ± .22	.80
	ECCENTRIC	PT (Nm)	286.82 ± 48.76	287.71 ± 48.18	.98		286.82 ± 48.76	285.47 ± 51.35	.95
		avgVL (mV)	.765 ± .50	.685 ± .37	.88		.588 ± .27	.685 ± .37	.81
		avgRF (mV)	.469 ± .20	.481 ± .22	.80		.426 ± .17	.481 ± .22	.63
		avgVM (mV)	.608 ± .25	.536 ± .22	.90		.597 ± .30	.536 ± .22	.75

CoP MEASURES OF POSTURAL CONTROL IN PSYCHIATRIC PATIENTS

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AIM: Suggestions of motor disturbance related to psychotic conditions are corroborated by observations of schizophrenic patients showing high prevalence of dyscoordination, abnormal posture and proprioception, implying cerebellar impairment. However, only one controlled study on posturographic measurements exists. Abnormal sway was found in patients by means of 10s assessments. The present study aimed to test the hypothesis that psychotic patients have increased postural sway and to examine the underlying control mechanisms.
METHODS: This is an ongoing study. Resident psychotic patients in a psychiatric ward were referred by the responsible physician. To date 9 patients (age 19 – 34) were tested. The control group consisted of 28 age matched healthy persons. Postural control was tested on a force platform (Good Balance, Metitur, Finland) for quiet stance during three minutes for each of the following three conditions: eyes open, eyes closed and standing on an Airex balance pad with eyes open. All conditions were performed in the Romberg position with arms folded across the chest and without shoes. The posturographic data was analyzed for different parameters of centre of pressure (CoP). The area of CoP migration was determined for the overall size of sway. A Sway Density (SD) analysis was used to assess structural components of CoP in order to examine the underlying control parameters. RESULTS: The results confirm the hypothesis that postural sway was increased in psychotic patients. The CoP area was larger in patients than in healthy controls. The mean distances between the SD-curve peaks were greater in the patient group and the mean duration of the peaks were correspondingly shorter. There was no difference in mean time between the peaks. As an effect of condition, CoP area and SD-curve peak distance increased and duration of peaks decreased with modulation of sensory input in both groups. These effects were larger in the patient group, in particular for "pillow" which was reflected in an interaction between group and condition.
CONCLUSION: As CoP is proportional to the ankle torque it displays the control mechanism and not the controlled variable. The intrinsic feedback from the ankle muscles does not sufficiently provide control and is complemented by a feed forward postural control mechanism assumed to be reflected by SD variables. These results indicate a reduced or perturbed feed forward control in the psychiatric patient group.

Table 1: Outcome measures: centre of pressure (CoP), means / SD. Main effects of group.

Variable	**Patient group**			**Control group**			***p***
	Eyes open	**Eyes closed**	**Pillow**	**Eyes open**	**Eyes closed**	**Pillow**	
CoP area (mm^2)	342/ 237	429/ 108	1861/ 1449	171/ 93	237/ 131	1397/ 262	.000
SD-curve peak distance (mm)	3.2/1.1	3.7/1.3	9.8/3.0	2.2/0.6	3.0/1.1	6.9/1.7	.001
SD-curve peak duration (s)	1.7/.06	1.3/.4	.5/.2	2.6/1.0	1.8/.9	.7/.1	.026
Time between SD-peaks (s)	.59/.02	.58/.02	.62/.02	.61/.03	58/.03	.60/.02	ns

REST TIME ANALYSIS OF SEMG APPLIED IN BIOFEEDBACK INTERVENTIONS ADDRESSING NECK PAIN AT WORK

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AIM: “Work-related” neck pain, i.e. pain that develops over time and not directly linked to a traumatic event, is attributed to an interplay between individual as well as (workplace) physical and psychosocial factors. Few studies have been performed addressing neck pain at the workplace, and those performed typically have been limited to one of these three risk dimensions. The use of biofeedback to make the employee aware about work tasks and working situations that result in unfavourable muscle activation may highlight problems in all three risk dimensions; the individual, in terms of e.g. work technique, the physical, in terms of e.g. work station layout, and the psychosocial, in terms of e.g. work organisation.
METHODS: This study regards relative rest time (RRT), i.e. the percentage of time where the muscle has been relaxed or in a rest-like condition, as a measure to identify unfavourable muscle activation of the trapezius muscle, and, a biofeedback service where the use of a RRT-based biofeedback system at the workplace (1) is augmented by weekly consultations with an ergonomist or physiotherapist. In addition to the employee’s immediate response to each specific biofeedback alarm while working, the weekly consultations, which are based on last week’s myoelectric recordings, available from the biofeedback system, and the performed work, available from a diary kept by the employee, makes it possible to get professional input on how to cope with those working situations resulting in biofeedback alarms.
RESULTS: A first large-scale randomized controlled trial (RCT) testing four weeks of biofeedback treatment at the workplace compared to ergonomic counseling showed improvement in pain and pain-related disability in both the intervention and control group (2). A second RCT study, which added a telemedicine dimension in order to rationalize the weekly consultations by enabling remote monitoring and counseling by telephone, showed similar improvement in pain, pain-related disability, and work ability in the intervention group and the control group following traditional care (3).
DISCUSSION: The presented biofeedback approach allows employees to take part in muscle relaxation training and get input on how to change their working practice while performing their regular work. Further research is needed regarding unfavorable muscle activation patterns and what to do in response to alarms depending on the working situation. It is believed that the presented approach can be a valuable tool in occupational health service to address neck pain at the workplace.

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EMG IN HIGHLY DYNAMIC MOVEMENTS – SCOPE, CHALLENGES AND METHODOLOGICAL CONSIDERATIONS

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AIM: (1) Provide an overview on applications and perspectives for using electromyography (EMG) in the biomechanical analysis of sport movements. (2) To give examples from a study where EMG measurements were compared to model-based calculations of muscle activity.
METHODS: (1) Five internationally acknowledged researchers will present and discuss their most current work on dynamic sport movements and the use of EMG. It will be aimed at sharing experiences to improve data collection and interpretation. (2) The workshop organizer will present results from a study on change of direction tasks where a musculoskeletal model and EMG measurements were compared.
Fourteen healthy subjects without any ankle or lower extremity restraint (age: 25+/-2.7 y; height: 179+/-3 cm; body mass: 78.4+/-3.8 kg) were asked to carry out 90º cutting manoeuvres while making contact with a force platform with their right foot. The plate was covered with 2 mm thick rubber to generate sufficient friction between shoe and surface. The plate was mounted onto a custom-built robotic platform allowing to induce horizontal movements simulating slipping during the early contact phase. Ground reaction forces (GRF) (AMTI, 2000 Hz) and 3-dimensional kinematics (Qualisys Oqus, 250 Hz) were recorded. EMG signals of eight muscles of the right leg were recorded (biovision, 2000 Hz). Joint moments at the ankle, knee and hip joints were calculated using an inverse dynamics approach and muscle forces determined using an optimization algorithm (AnyBody Modeling System 4.1.0, AnyBody Tech). Average EMG envelopes were correlated with calculated muscle activations.
RESULTS: Marginal alterations in measured EMG signals and calculated muscle forces were found across the different slip conditions. In general, the modeled and measured muscle activities showed good agreement (Fig. 1). However, some muscle groups with measured preactivation showed low correlations. Ankle and hip kinematics were altered notably when the platform moved while the knee action remained relatively stable.
CONCLUSION: The consistency of muscular activity under different unexpected slip conditions indicates a stable neural control pattern even under perturbed movement execution. The kinematic full body analysis revealed a strong influence of upper extremity movements during slips. Further research into the underlying mechanisms is warranted.

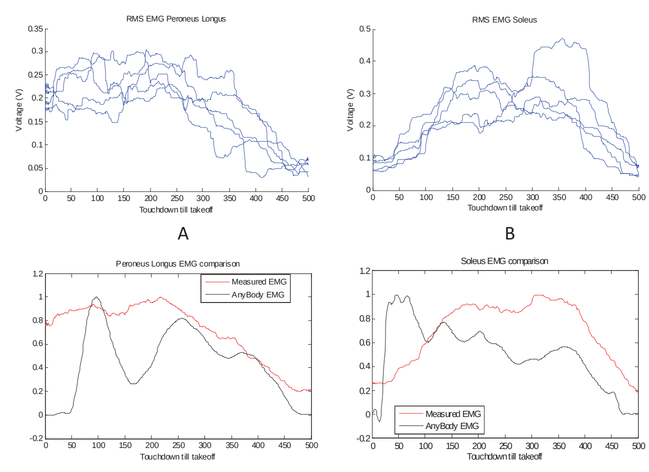

Figure 1: Example of trial by trial EMG envelopes for peroneus (A) and soleus (B). Average of measured EMG and EMG activation from the model, (C) and (D).

SUSTAINED FIRING MEASURED BY HIGH DENSITY SURFACE EMG

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AIM: Sustained firing, i.e. motor unit (MU) firing that continues after a stimulus has ended, has been suggested to play a role in disturbed motor control in patients with upper motor neuron syndrome [1]. Sustained firing can be evoked by mechanical vibration of the distal muscle tendon and can be measured using intramuscular EMG (iEMG) [2]. However, the reproducibility of iEMG is limited due to the small recording volume and may influence motor control due to its invasive character. This study aims to determine whether sustained firing can be assessed non-invasively in a controlled manner with an instrumented experimental setup in combination with High Density-surface EMG (HD-sEMG), that showed good reproducibility [3].
METHODS: Ten healthy subjects were seated with their arm immobilized. The subjects were asked to relax their arm. A position-controlled linear actuator was used to provide a pre-tension, followed by a sinusoidal vibration (6s) to the distal biceps brachii tendon. 10 different conditions (variations in pre-tension, amplitude, stimulation time and frequency) were applied. Stimulation was started when no muscle activity was observed. Muscle activity was measured during and after stimulation by a 2D 32 channel electrode array with an inter-electrode distance of 5 mm. Single motor unit action potentials (MUAPs) were extracted by decomposing the signals by segmentation, feature extraction and classification [4].
RESULTS: In five subjects MUs, that continued firing after the stimulus was ended, were detected. Figure 1 shows an example in which sustained firing of 5 MUs was detected. Duration of the sustained firing varied between seconds and minutes. Preliminary analysis showed no difference between the applied conditions. However, a trend was observed toward a decline of MU activity during the course of the experiment.
CONCLUSION: It seems possible to evoke and assess sustained firing non-invasively in healthy subjects. The various conditions tend not to have influence on the results, however adaptation might be present. Further analysis aims at identifying factors that determine if sustained firing is evoked. Next step in research is assessment of the reproducibility of the method and testing the method in subjects with upper motor neuron lesion.

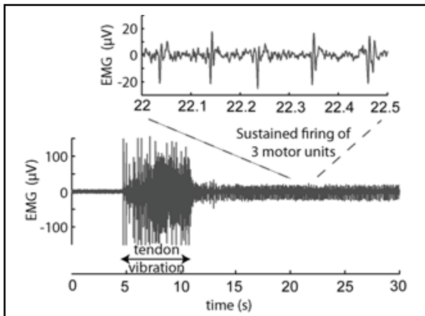

Figure 1: A bipolar derivation of the HD-sEMG. Before the stimulus no activity was shown. Sustained firing is detected after the stimulus. Sustained firing of 3 MUs about 10s after stimulus was ended. (‘tendon vibration’: 5N, 2.5 mm, 6s, 80Hz)

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PREDICTING THE ENTIRE SPECTRUM OF FEMORAL LOADS DURING WALKING

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AIM: Although current musculoskeletal simulations provide an optimal solution of the muscle redundancy problem, the ability to investigate the entire spectrum of muscle activation strategies would help in understanding critical skeletal conditions. Aim of the study is to numerically identify and sample the whole spectrum of possible hip muscle activation strategies during a selected frame of walking.
METHODS: A generic musculoskeletal model (Delp, IEEE Trans Biomed Eng.;37(8)) was registered onto a skeletal anatomy (female, 81 yr, 63 kg, 167 cm) from a public repository (www.physiomespace.com). 3D motion (Vicon Motion Capture, Oxford UK) and ground reaction forces during walking were recorded from a selected volunteer (female, 25 yr, 57kg, 165cm). A preliminary simulation was run using traditional optimisation techniques. An orthonormal base of activation patterns was computed from the redundant equilibrium equation for the maximum HR frame. Admissible muscle forces were assumed between zero and the maximum isometric force, parameterized in terms of physiological cross section area (PCSA) and tetanic muscle stress (TMS). The spectrum of possible activations was sampled by generating 10^5 random linear combinations of base vectors setting 7 different TMS values within published range (0.35-1.37 Mpa. Buchanan, J Appl Biomech. 20(4)). The highest (HRh) and the lowest (HRl) hip reaction for a given TMS were also calculated (Figure 1).
RESULTS: The preliminary exploration of the muscle activations space showed that several muscles varied between silent to fully activated, producing large HR variations. HRl (3-3.7BW) was slightly sensitive to TMS changes, similarly to what observed in optimisation solutions. Conversely HRh showed a high level of muscle co-contractions and a high sensitivity to TMS changes: HRh increased from 9.2 to 23.2BW, a range from physiological (9BW) to very likely non-physiological (23.2BW).
CONCLUSION: The proposed method allowed sampling the whole space of solutions, representing a possible extension of traditional optimisation techniques to identify and study critical condition of skeletal stresses in sub-optimal neuro-muscular control conditions. To this purpose, a precise identification of TMS seems to be of great importance.
ACKNOWLEDGEMENT: This study was partially funded by the EC-funded projects LHDL (IST-2004-026932) and VPHOP (Grant #223865)

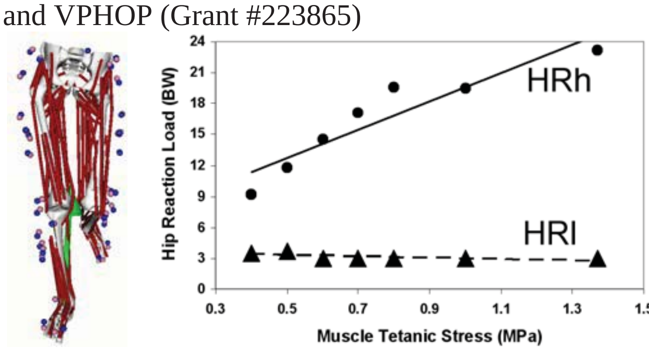

Figure 1: On the left the musculoskeletal model in the studied frame and on the right the scatter plots and regression lines of HRl and HRh

SPONTANEOUS MOTOR UNIT ACTIVITY DETECTED BY SURFACE ELECTRODE ARRAY IN HEMIPARETIC STROKE SURVIVORS

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AIM: This study seeks to perform a surface electrode array EMG examination of muscles in hemiparetic stroke patients, with a view to assessing the potential role of motoneuron and muscle fiber degeneration in promoting muscle atrophy. In particular, we focused on detection and analysis of spontaneous motor unit activity of hemiparetic muscles to determine whether there was evidence for motoneuron degeneration.
METHODS: The subjects were comfortably seated in a chair. There were no disturbing stimuli in the measurement room. The arm was placed in its natural, resting position. The subjects were completely relaxed. Surface EMG signals were then recorded for 10-20 minutes in relaxed condition from three upper limb muscles. A home-manufactured 1-dimensional (20-channel) linear bar electrode array was used for recording of biceps brachii muscles, while a flexible 2-dimensional (64-channel arranged in an 8×8 square matrix) electrode array (TMS International BV, the Netherlands) was used for recording of two hand muscles, the first dorsal interrosseous (FDI) and the abductor pollicis brevis (APB).
RESULTS: Different spontaneous motor unit activities were observed from 4 hemiparetic stroke survivors (Figure 1). One type of spontaneous activity is motor unit discharges with regular rates (similar to voluntary motor unit discharges at very low muscle contraction levels). A different type of spontaneous activity is motor unit discharges with random and slow rates (similar to fasciculation potentials observed from amyotrophic lateral sclerosis). Finally, we also observed spontaneous motor unit activity with repetitive discharges.
CONCLUSION: The electrode arrays serve an appropriate approach for capturing a muscle's spontaneous activity. The spontaneous motor unit activity observed in this study may suggest trans-synaptic degeneration of lower motoneurons after an upper motoneuron lesion.

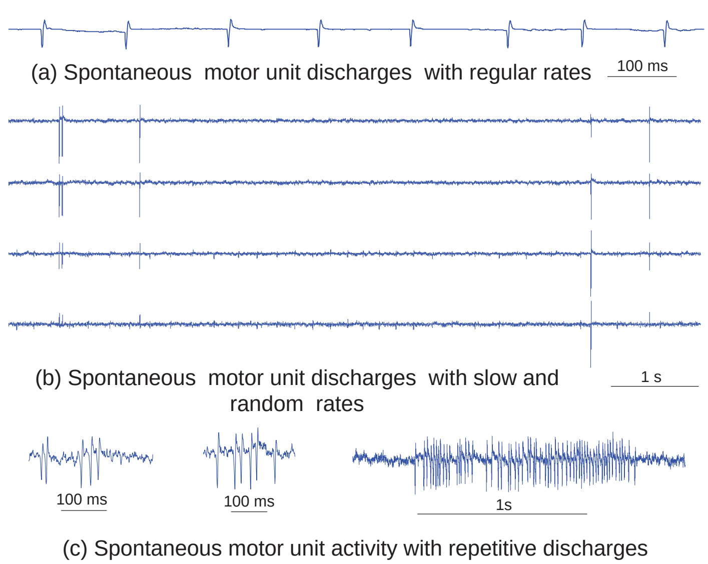

Figure 1: Different spontaneous motor unit activities observed in hemiparetic muscles

NEUROMECHANICAL PERFORMANCE AND NON−CONCURRENT STRENGTH AND ENDURANCE CONDITIONING FOLLOWING LIGAMENT RECONSTRUCTION SURGERY.

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AIM: Assessment of the effectiveness on neuromechanical performance of a new formulation of conditioning following anterior cruciate ligament (ACL) reconstruction surgery involving standardised segregation of strength and endurance exercises designed to minimise physiological inhibition to conditioning.
METHODS: Neuromechanical performance capabilities were assessed in the knee extensor musculature of the involved and contralateral control limbs prior to unilateral ACL-reconstruction surgery (at the recruitment to the study); 6 weeks post-surgery; 12 weeks post-surgery; 24 weeks post-surgery; 36 weeks post-surgery and 48 weeks post-surgery in participants randomly assigned into three groups: (i) a control, accelerated programme of exercise conditioning (CONTROL A, n=7; age: 22.6 (± 2.9) yrs; height 1.78 (± 0.06) m; body mass 73.8 (± 6.7) kg (mean [± SD]) used in current clinical practice focusing on progressive mobility, strength and endurance conditioning, (ii) a control condition (CONTROL B, n= 7; age: 21.9 (± 2.0) yrs; height 1.79 (± 0.05) m; body mass 74.4 (± 7.3) kg) quantifying the influence of the test administrator and assessment procedures, and (iii) a modified programme of exercise conditioning (EXPERIMENTAL, n=8, age: 23.1 (± 2.1) yrs; height 1.77 (± 0.09) m; body mass 72.7 (± 6.0) kg) involving specific phasing of strength and endurance exercises.
RESULTS: Results from mixed-model ANOVA of acute responses to conditioning (0 – 12 weeks post-surgery) suggest that whereas the neuromechanical performance capabilities associated with the involved limb of the control group (CONTROL A) showed relatively large deficits compared to baseline (pre-surgery) (up to 72%, 65% and 82% reduction, respectively in peak force [195 ± 72 N vs. 456 ± 72 N], electromechanical delay (volitional) [51.4 ± 11.2 ms vs. 34.3 ± 9.3 ms; knee flexors, 6 weeks post-surgery], rate of force development [355 ± 45 $N \cdot s^{-1}$ vs. 1350 ± 60 $N \cdot s^{-1}$; knee extensors, 12 weeks post-surgery]), the performance capabilities of the EXPERIMENTAL group were preserved more effectively during this period of rehabilitation (up to 35%, 42% and 36% reduction, respectively in peak force [275 ± 67 N vs. 440 ± 65 N;], electromechanical delay (volitional) [36.7 ± 9.2 ms vs. 28.3 ± 7.3 ms; knee flexors, 6 weeks post-surgery], rate of force development [955 ± 65 $N \cdot s^{-1}$ vs. 1350 ± 60 $N \cdot s^{-1}$; knee extensors, 12 weeks post-surgery]; $F_{[10, 65]} = 3.4$ to 5.6; $p<0.05$).
CONCLUSION: The findings show that phasing of strength and endurance exercises within rehabilitative conditioning programmes offer a significant acute enhancement to the preservation of performance capabilities associated with dynamic stabilisation of the injured joint system.

A MODEL OF THE EMG SIGNAL INCORPORATING ION CHANNEL PROPERTIES

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AIM: The aim of this study was to develop a model of the electromyographic (EMG) signal that incorporated details of the muscle fiber action potential including ion channel properties and muscle temperature.
METHODS: The transmembrane current density was simulated using a model of the propagating muscle fiber action potential that captured the sodium, chloride and delayed, inward rectifier and slow potassium currents, the sodium potassium pump, transverse tubular system and temperature scaling. The impulse response detected at the surface EMG electrode due to a unit point current source propagating along the muscle fiber was calculated for each muscle fiber using a finite element volume conductor model. The surface action potential was then calculated as the convolution of the impulse response of the volume conductor model and the transmembrane current density with start-up and end-effects incorporated at action potential generation and extinction. The transmembrane action potential was assumed to propagate with uniform velocity and maintain a constant spatial distribution along the fiber.
RESULTS: The simulated transmembrane action potential for a muscle fiber of diameter 40 μm is presented in Figure 1(a), for a range of extracellular potassium concentrations. The corresponding single fiber action potentials detected at the skin surface above a 5 mm deep muscle fibre are presented in Figure 1 (b). As extracellular potassium increased, both the transmembrane potential and single fiber action potential broadened, delayed and decreased in amplitude.
CONCLUSION: A multi-scale model of the surface EMG signal has been developed to enable the effect of variations in muscle fiber ion channels properties, ion concentrations and muscle temperature to be examined. The model enables a range of normal and pathological conditions to be simulated, that can not be captured using traditional dipole, tripole or analytical source representations. It offers the possibility of exploring the effect of changes at the ion-channel, transverse tubular system and sarcolemma level on the surface EMG signal.

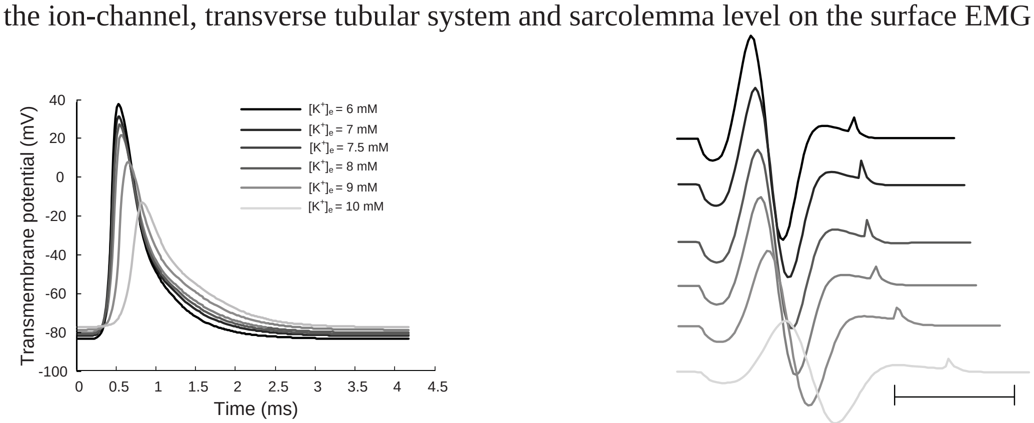

Figure 1: (a) Transmembrane muscle fibre action potentials simulated for increasing extracellular potassium concentration, $[K^+]_e$, at 37°C. (b) Corresponding single fibre action potentials detected at the skin surface 5 mm above the muscle fibre.

THE MANUFACTURE OF THE ANTEROR CRUCIATE LIGAMENT REPRODUCTION MODEL

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AIM: It is generally recognized that an anterior cruciate ligament (ACL) rupture is heal rarely with conservative treatment. Although ACL rupture under a certain condition can be healed by the kinesiological treatment using the special knee brace. We hypothesized that an acute ACL tear is healed conservatively by the joint movement without extending a damaged ligament excessively from the early stage just after injury.
METHODS: This study was approved by the Ethics Committee of the Saitama Prefectural University. Five10-weeks-old (group 1) and ten 26-weeks-old (group 2 and 3) Wistar male rats were used. After transecting right ACL completely, (1) the suture thread (3-0) was penetrated behind medial and lateral epicondyles of femur, and was through to a patella tendon, and was sewed up in the outside (group 1), (2) the suture thread was penetrated under the distal quadriceps femoris, was through to a tunnel of tibial crest, and was sewed up in the outside (group 2), (3) the suture thread was penetrated behind medial and lateral epicondyles of femur, was through to a tunnel of tibial crest, and was sewed up in the outside (group 3). During 12 weeks after operations, all rats were bred in a cage freely, and killed by an injection of Pentobarbitalnatrium. The knee joint was observed visually.
RESULTS: In the group 1, inflammation and destruction of the cartilage were recognized right knees of all rats, and three rats could be appeared a shin reproduction ACL. Agria was observed on the lateral epicondyles of two rats. In the group 2, we could observe a thin ACL in right knee joints of all rats, but light inflammation and destruction of the cartilage were recognized. In the sagittal plane image of the knee joint, the run of the suture thread was different from a run of the normal ACL. On the contrary, we could observe a thick ACL all rats in the group 3, and the inflammation and the destruction of the cartilage were hardly recognized. In the sagittal plane image of the knee joint, the run of the suture thread resembled a run of the normal ACL.
CONCLUSION: The height and weight of rat is increased with progress of time. In the group1, the suture thread was penetrated the patella tendon, and the thread was pulled backward and moved in the knee joint with the growth of the rat. The growth of the rat blunts over 24-weeks-old. Because the suture thread was fixed by the bone, the front of the thread was not moved backward. The knee joint was moved normally by it. It is suggested that the normal kinematic movement promotes ACL reproduction in acute period of ACL injury.

THREE-DIMENSIONAL ANALYSIS OF MANDIBULAR MOTION IN HEALTHY YOUNG MEN AND WOMEN

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AIM: In humans mouth opening requires a simultaneous combination of rotation in the lower temporomandibular joint compartment (condyle-disk) and translation in the upper compartment (glenoid fossa-disk). The clinical measurement of the maximum mouth opening (MMO) cannot provide accurate information about condylar movements. The aim of the current investigation was to quantitatively assess the three-dimensional condylar paths in healthy subjects performing standardized mandibular movements.
METHODS: The investigation required the non-invasive acquisition of mandibular movements using an optoelectronic motion analyzer, with a 60 Hz sampling rate (BTS Smart System). Twenty healthy subjects (10 men, 10 women) performed mouth opening and closing, right and left laterotrusions, mandibular protrusion and retrusion. Nine passive markers (diameter 5 mm) were used: three created a cranial reference system; three, positioned on a stainless steel extraoral frame fixed on the mandibular anterior gingival, provided the mandibular reference system; two individualized the condylar reference points, and one corresponded to the interincisal point. The three-dimensional pathways of the interincisal and the two condylar reference points were evaluated for each movement; in opening and closing the decomposition in rotation and translation was also assessed.
RESULTS: All mandibular movements showed symmetric paths. In both opening and closing, the rotating component (increasing in opening and decreasing in closing) was always greater than the translation one, but never approaching 100% (fig. 1). MMO was significantly related to the sagittal angle at maximum mouth aperture (P=0.001), but not to condylar translation. Overall no significant gender differences were observed, except a larger downward motion performed by men's condyles during mouth opening (U-test: P=0.002 and P=0.048 for right and left condyles respectively), probably due to a steeper articular eminence of the temporal bone. No correlations were found between MMO and the maximum excursions in both laterotrusions and protrusion. Retrusions were all negligible.
CONCLUSION: These findings characterize a healthy control group, and will enter in a reference database for oncoming surveys on pathological or pre/post surgical patients.

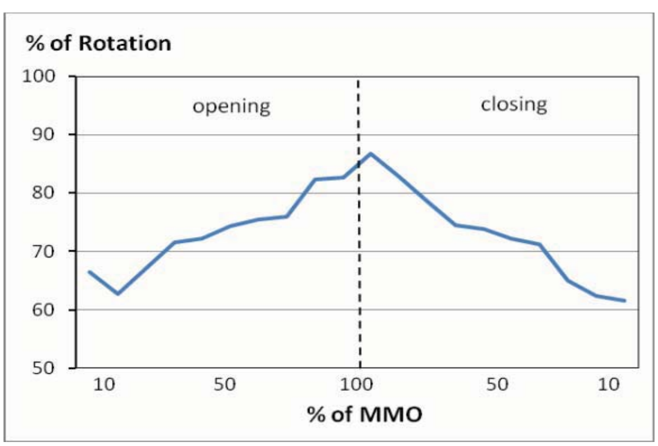

Figure 1: Percentage of mandibular rotation during mouth opening and closing.

RELIABILITY TESTING OF POSITION MEASURES FOR A 3D MOTION TRACKING DEVICE

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AIM: The objective of this study was to describe characteristics such as variability and repeatability through examination of instrument and test-retest reliability for a 3D motion tracking device based on tracking of sensors in an electromagnetic field (LIBERTY™, Polhemus Inc.). We examined the variability in sensor signals in relation to the distance from transmitter, and the effect of objects of different materials in the electromagnetic field.
METHODS: The instrument's 3D position measures (x, y and z) were tested at rest with the sensor positioned in a custom made wooden test rig. The sampling frequency was 240 Hz for each sensor. The distance between transmitter and sensor was systematically varied along the x - axis. A human arm and an EMG electrode, and objects made of brass, lead, iron, wood, Teflon® and brick were systematically introduced in different positions related to the transmitter and sensors.
RESULTS: The instrument provided stable position measures i.e. no drift nor baseline shift was observed in any of the three dimensions. The variation in position measures in all three dimensions increased with increasing distance to transmitter (figure). SD values for sensors in all positions within 90 cm from transmitter were less than 0.5 mm. Metallic objects, such as lead, brass and iron affected the system by giving altered mean position measures. Off sets up to 6 mm were observed, with largest effect for iron. A human arm, an active EMG electrode, Teflon® and brick did not affect the position measures. Stability over time were tested by calculating mean values and SD for position data for time intervals ranging 0.025 s to 1800 s. The largest range was less than 0.1 mm. Repeatability when tested on a sensor that was repeatedly moved between two fixed positions was almost of the same magnitude as the instrument repeatability i.e. SD increased similarly to that shown in the figure.
CONCLUSION: When sensors are positioned within 0.9 m distance to transmitter and the presence of metallic objects is limited, the instrument provides repeatability and stability sufficient for most physiological and clinical studies.

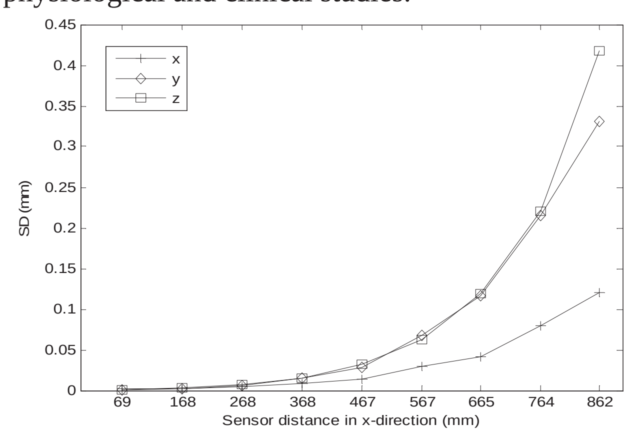

Figure: SD for a sensor positioned at increasing distance to transmitter. SD are shown for each position in all three dimensions and are drawn as separate lines. SD calculated on a time interval of one second. Sensor positioned at nine different positions along an orthogonal track related to transmitter.

THREE-DIMENSIONAL ANALYSIS OF STANDARDIZED FACIAL MOVEMENTS: EFFECT OF AGE AND SEX IN HEALTHY ADULTS

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AIM: Functional impairments of facial movements alter the quality of life, and their quantitative analysis is a key step in the description and grading of facial function and dysfunction. The first step is the definition of reference values in normal persons; for instance, the effect of aging on facial movements is still debated. Age and sex effects on 3D facial movements during the performance of standardized facial animations were assessed.
METHODS: Twenty healthy younger adults (10 men, 10 women; aged 20-30 y) and 20 older healthy adults (9 men, 11 women; aged 40-50 y) were filmed by a 3D motion analyzer during the performance of seven standardized facial movements (right side eye closure; left side eye closure; eye closure; maximum smile; free smile; "surprise" with closed mouth; "surprise" with open mouth). The 3D coordinates of 21 soft-tissue facial landmarks (forehead, eyes, nose, mouth) were recorded, their displacements computed, and standardized for facial dimensions. Comparisons were made by analyses of variance.
RESULTS: On average (fig. 1), men had larger movements than women (except maximum smile in both younger and older adults, and free smile in the younger adults), but the differences were not statistically significant. During "surprise" with closed mouth, there was also a significant asymmetry of both mouth and nose (women, right side; men, left side). Older subjects had significantly ($P<0.05$) smaller movements than younger subjects during the execution of unilateral eye closures, free smile, "surprise" with closed mouth and "surprise" with open mouth. Younger subjects also showed a significantly larger asymmetry of mouth ($P=0.001$) and nose ($P=0.004$) during right side eye closure.
CONCLUSION: Standardized facial movements were performed with similar displacements in normal men and women, but they reduced with aging. Both the age-related reduction in elastic fibers in facial dermis, and psychological aspects may partly explain these results. Data can be used for the quantitative analysis of the impairments of patients with facial palsy.

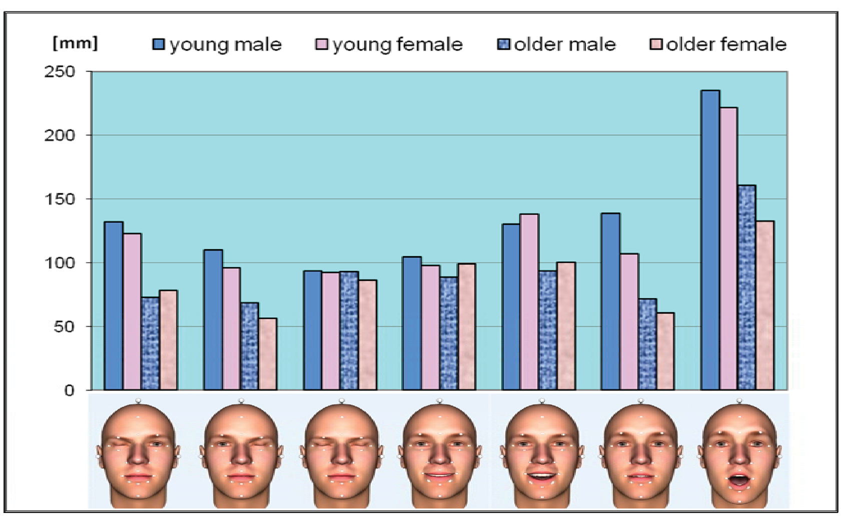

Figure 1: Mean values of the total mobility index.

MIDDLE-AGED WOMEN DEMONSTRATE FATIGABILITY OF HAMSTRINGS WITH EXHAUSTIVE EXERCISE

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AIM: Fatigue protocols often involve high-intensity contractions over short periods. However, activities of daily living that induce fatigue involve prolonged or repetitive contractions. We aimed to compare quadriceps and hamstrings fatigability from the beginning to the end of exhaustive exercise, in young versus middle-aged women.
METHODS: Eight healthy young women (24.1 ± 0.8 years, 24.4 ± 5.7 kg/m^2 BMI) and 7 healthy middle-aged women (55.4 ± 4.5 years, 24.9 ± 3.2 kg/m^2 BMI) participated. They were instrumented with bipolar surface electrodes (Bortec Biomedical Ltd., AB, Canada) over the rectus femoris and biceps femoris of the dominant leg and positioned on an isokinetic dynamometer (Biodex Medical Systems, Shirley NY). Baseline measures included peak knee extensor and flexor torque at 60°/s and EMG median power frequency (MnPF) during a 10% maximum voluntary isometric contraction. To induce fatigue, participants repeated sets of 50 concentric extensions and flexions at 60°/s. Immediately following each fatiguing set, peak torque (isokinetic) and EMG MnPF (isometric) measures were repeated and pain and perceived exertion recorded. Fatiguing sets continued until peak torque of both muscles dropped by ≥25% from baseline, excessive pain/exertion, or the completion of 10 sets. A shift in EMG MnPF confirmed neuromuscular fatigue. A fatigue index calculated the percent decrease in torque output over each set of fatiguing contractions. A two-way analysis of covariance (with baseline torque as a covariate) was calculated to identify whether 1) middle-aged women had a higher fatigue index than young women and 2) the fatigue index increased from the first to the last set of exhaustive exercise.
RESULTS: Young women had greater baseline quadriceps and hamstrings peak torque (145.6 ± 28.8, 66.4 ± 11.5 Nm respectively) compared to middle-aged women (100.0 ± 24.7, 45.2 ± 11.3 Nm respectively, $p<0.01$). The young (6.8 ± 2.1 sets) and middle-aged (6.9 ± 2.6 sets) groups completed the same number of sets of fatiguing contractions. A main effect of age showed that middle-aged women had greater hamstrings fatigue indices compared to young women ($p=0.04$, Table 1). No differences in fatigue index were found between the first and last sets of fatiguing contractions.
CONCLUSION: Compared to young, middle-aged women showed greater fatigability of hamstrings with exhaustive exercise. These findings appear to contradict several studies that demonstrate fatigue resistance in older women compared to younger women. However, most of these studies utilize shorter protocols (e.g., 30-100 concentric contractions, 10-60s isometric contractions) [Kent-Braun, 2008]. Ongoing data collection and analysis will examine EMG data. Future work should examine whether hamstrings fatigue facilitates the increased prevalence of knee problems, such as osteoarthritis, in middle-aged women.
ACKNOWLEDGEMENT: NSERC (Canada) Discovery Grant #353715 (MM).

Table 1: Fatigue indices, reflecting the percentage decrement in peak torque output, for quadriceps and hamstrings in young and middle-aged women.

Age Group	**Young Women**		**Middle-Aged Women**	
Time	**First**	**Last**	**First**	**Last**
Quadriceps Fatigue Index	38.2 ± 17.0	38.8 ± 9.0	39.1 ± 8.1	41.5 ± 13.7
Hamstrings Fatigue Index	28.8 ± 13.4	32.7 ± 12.6	40.0 ± 12.7	35.4 ± 18.4

LINEAR VS NON-LINEAR MUSCLE POWER MAPPING USING SURFACE EMG VARIABLES DURING DYNAMIC FATIGUING CONTRACTIONS

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AIM: To compare the performance of linear muscle power mapping (multiple regression) and non-linear mapping (neural network) using surface EMG variables during dynamic fatiguing contractions.
METHODS: 15 healthy men performed 5 sets of 10 maximum leg presses, with 2 min of rest between sets. Mechanical power output and bipolar surface EMG from the vastus lateralis and medialis muscles were recorded. The following variables were computed from the surface EMG: Mean average voltage (MAV), median spectral frequency (Fmed), Dimitrov's spectral index[1] (FInsm5), average (over the observation interval) of the instantaneous mean frequency obtained from a Choi-Williams distribution (MFM) and indices extracted from the coefficients of the dyadic wavelet transform (WIRM1551, WIRM1M51, WIRW51, WIIRE, WIRM1522) [2]. FInsm5 and the wavelet indices were log-transformed since they did not follow a normal distribution. The values of each variable for the two muscles were averaged. To quantify the performance of the two techniques a signal-to-noise ratio (SNR) metrics between the real and the estimated muscle power output was calculated.
RESULTS: The neural network provided higher correlation coefficients and SNR values (although not significantly different) between the actual power output and the estimated value compared to linear regressions (Table 1). Furthermore, using a two factor combination predictor of Log-WIRW51 and MFM (obtained by a stepwise multiple linear regression), the performance obtained with the neural network (R=0.77; SNR=8.42) was higher, but not significantly different, than using multiple regression (R=0.73; SNR=7.77).
CONCLUSION: Non-linear mapping using a neural network provides better prediction of muscle power than linear mapping from variables extracted from the surface EMG. However, the differences are limited, which indicates that an approximate linear relation well describes the association between surface EMG variables and muscle power during fatiguing dynamic tasks.
ACKNOWLEDGEMENT: Public University of Navarre, the Spanish Ministry of Education and Science (Ref: DEP2006-56076 and SAF207-65383).

[1]Dimitrov et al. Med. Sci. Sports Exerc., 2006;38:1971-9.
[2] Gonzalez-Izal et al. WASET, 2009;55:480-485.

Table 1: Correlation coefficient and SNR between estimated and real power output.

	MAV	**Fmed**	**Log-FInsm5**	**MFM**	**Log-WIRM1551**	**Log-WIRM1M51**	**Log-WIRW51**	**Log-WIRE**	**Log-WIRM1522**
Linear Regression	-0.34 (5.66)	0.49 (6.12)	-0.59 (6.60)	0.57 (6.47)	-0.70 (7.45)	-0.70 (7.46)	-0.72 (7.61)	-0.71 (7.54)	-0.71 (7.50)
Neural Network	-0.38 (5.73)	0.52 (6.23)	-0.68 (7.22)	0.62 (6.79)	-0.74 (7.96)	-0.75 (8.00)	-0.76 (8.12)	-0.75 (8.09)	-0.75 (7.99)

TRANSIENT QUASI-STATIC PASSIVE MODEL OF THE UPPER LIMB UNDER SURFACE ELECTRICAL STIMULATION: FINITE INTEGRATION BASED APPROACH

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AIM: In this contribution, we present an accurate 3D electromagnetic model for the human upper limb under surface electrical stimulation. We adopt the volume conductor representation to determine the electromagnetic field distribution inside the arm, in order to derive the current density and the potential map across all the involved tissues. Following a classical two step procedure [Khun *et al.*, 2009], this approach may be used then to analyze the passive tissues response to transcutaneous functional electrical stimulation (FES), providing the input values to an active model describing nerve fibres behaviour in order to properly apply FES for tremor suppression.
METHODS: We developed a robust transient quasi-static model, based on a finite integration time-domain solver (CST EM Studio®), involving a simplified cylindrical multilayered structure, where the human tissues (i.e. skin, fat, bone cortical, bone marrow and muscle) are characterized by their conductive and dielectric properties. The introduction of the relative electric permittivity constant (determined from literature data) allows to include also the capacitive effects arising in the layers, typically neglected in the low frequency range associated to FES signals. Simulation were performed by applying a square wave excitation to a current line feeding two silver electrodes placed on a uniform homogeneous conductive gel layer applied above the skin.
RESULTS: The time-varying current density distribution across the whole structure (reported in Figure 1) has been numerically computed by the solver. The amplitude range is consistent with the results reported in literature [Khun *et al.*, 2009]. All the geometric and electric quantities concerning the model have been parameterized in order to straightforwardly analyze the structure for any change of the initial setup values.
CONCLUSION: A robust and accurate transient quasi-static passive model of the upper limb has been presented. The model describes the tissues response to surface electrical stimulation, providing the overall electromagnetic field distribution. The model may be successfully extended to determine the current and potential distributions inside the arm due to an array of electrodes used for an optimal design of a FES based tremor suppression system.
ACKNOWLEDGEMENT: We acknowledge the Commission of UE, which funded this research through grant ICT-2007-224051" TREMOR "An ambulatory BCI-driven tremor suppression system based on functional electrical stimulation".

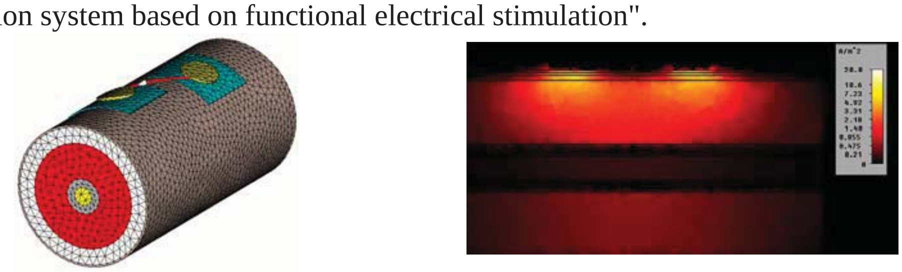

Figure 1: (left) Cylindrical multilayered model of the human upper limb, with tissue differentiation and excitation electrodes; (right) current density distribution across the structure at a given excitation instant (lateral view).

ACTIVE MODEL OF NERVES IN THE UPPER LIMB UNDER SURFACE ELECTRICAL STIMULATION

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AIM: Nerve fibres modelling for optimizing functional electrical stimulation (FES) is receiving an increasing interest in the scientific community [Rattay et al., 1993][Khun et al., 2009]. In the context of FES-based tremor suppression, we introduce an accurate model of the arm nervous system which is the active part of a two-step approach where the passive tissues (i.e. skin, fat, bone, muscle) are represented by means of a cylindrical finite element model (FEM). The active model reproduces nerve recruitment and arm behaviour when FES is applied via surface electrodes.

METHODS: The proposed model of the arm nervous system is a development of the double cable structure of axon of [McIntyre et al., 2002]. Axons are grouped in nerve bundles placed at different depths (0.6:1.5 cm; 0.1 cm spacing). Each bundle is composed of 100 axons whose typology and diameter are distributed in accordance with data from [Prodanov et al., 2007], while distances between consecutive nodes of Ranvier range from 0.4 to 1.6 mm. The model simulates nerve behavior and extracts the percentage of activated axons (nerve recruitment) when an adequate current stimulus is applied in correspondence to the nodes of Ranvier. Thus, inputs of the proposed model are the current values computed by FEM solver when electrical stimulation is applied. Outputs of the model are nerve recruitment and strength duration curve (SDC), defined by the couple of values (surface stimulation pulse duration and pulse amplitude) corresponding to nerve recruitment over 10% (as in Khun et al., 2009).

RESULTS: The model has been validated by comparing the results with experimental data from six healthy subjects whose biceps brachii has been electrically stimulated. Square wave pulses with frequency of 30 Hz, amplitudes from 0 mA to 25 mA (1 mA spacing) and duration from 100 μs to 1000 μs (50 μs spacing) have been applied both to subject's arm and to the model, via two surface Ag/AgCl electrodes of 1.5 cm diameter. Motor thresholds have been extracted and SDC values from the arm model are in the range of the ones obtained from the real electrical stimulation of the arm (Figure 1). Therefore, values from the proposed model are consistent with the experimental ones and in accordance with literature [Bostock, 1983][Khun et al., 2009].

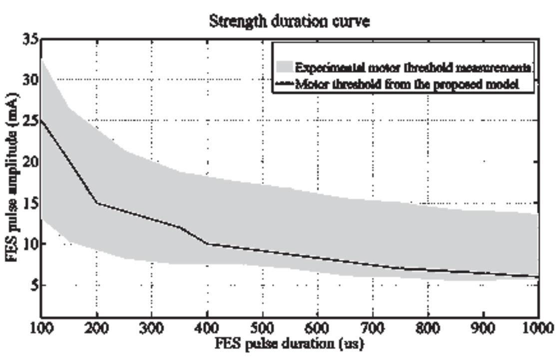

Figure 1: Strength-duration curves

CONCLUSION: An accurate model of the upper limb nervous system has been introduced. It reproduces nerve recruitment and arm behaviour in accordance with experimental data. In the context of FES-based tremor suppression, the model can be a useful tool for selecting the best electrode's configuration and the adequate stimulation parameters for an effective and painless muscle contraction.

ACKNOWLEDGEMENT: Thanks to the Commission of UE, which funded this research through grant ICT-2007-224051" TREMOR "An ambulatory BCI-driven tremor suppression system based on functional electrical stimulation".

CUMULATIVE KNEE ADDUCTOR LOAD DISTINGUISHES BETWEEN HEALTHY ADULTS AND ADULTS WITH KNEE OSTEOARTHRITIS

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AIM: Two individuals with identical peak adduction moments (proxy for medial knee loading), but different physical activity levels, experience different overall exposures to medial knee loading. Cumulative knee adductor load (CKAL) considers both loading repetition and magnitude to represent the total exposure of medial knee loading experienced during daily activity. We aimed to validate this measure by distinguishing between healthy adults and adults with knee osteoarthritis (OA) using CKAL.
METHODS: Thirty healthy adults (33.5 ± 8.0 years, 25.0 ± 4.2 kg/m^2 BMI) and 31 adults with radiographic knee OA (53.2 ± 6.1 years, 30.6 ± 4.2 kg/m^2 BMI) participated. Daily CKAL was the product of the stance knee adduction moment impulse and mean number of steps per day for one limb. The knee adduction moment impulse was calculated using gait data from 8 cameras (Motion Analysis Corp., Santa Rosa, USA) at a sample rate of 60 Hz and a synchronized floor-mounted force plate (AMTI, Watertown, USA) at a sample rate of 1200 Hz. A modified Helen-Hayes marker configuration was used, with 22 reflective markers. From the adduction moment waveform, the stance phase was integrated using the trapezoidal rule in a custom Matlab program (Mathworks Inc., Natick, USA). This impulse was not normalized to mass or height to represent the absolute load borne through the medial compartment. The mean number of steps taken daily was measured with a uni-dimensional accelerometer (ActiGraph, Fort Walton Beach, USA). Participants wore the accelerometer for 7 consecutive days over the midline of the affected thigh. An analysis of variance was calculated to determine whether CKAL was higher in the OA versus healthy group. The knee adduction moment peak and impulse and steps per day were compared between groups.
RESULTS: The CKAL and knee adduction moment impulse distinguished between the healthy and OA groups ($p<0.001$), such that the OA group experienced greater medial knee loading cumulatively during daily activity and during one stride (Table 1). Similarly, the peak knee adduction moment was higher in the OA group ($p<0.05$). The OA group took fewer steps per day than the healthy group ($p<0.05$).
CONCLUSION: The CKAL demonstrated excellent construct validity because this measure distinguished between healthy and radiographic knee OA groups. Though less active, the OA group had knee adduction moment impulses substantially higher than the healthy group, resulting in a higher CKAL. This large impulse in participants with knee OA was likely related to slowed gait speed and being overweight. Interventions for people with knee OA should focus on improving physical activity, while minimizing cumulative load.
ACKNOWLEDGEMENT: NSERC (Canada) Discovery Grant #353715 (MM).

Table 1: Cumulative knee adductor load, knee adduction moment peak and impulse and steps per day distinguished between healthy and OA groups (**$p<0.001$, *$p<0.05$)

	Knee OA (n=31)	**Healthy (n=30)**
CKAL (kNms)	80.80 ± 44.54	42.79 ± 28.11**
Knee Adduction Moment Impulse (Nms)	22.3 ± 10.7	9.5 ± 4.7**
Steps per day	7390.9 ± 2674.6	8762.3 ± 2716.0*
Knee Adduction Moment Peak (Nm/kg)	0.51 ± 0.13	0.42 ± 0.13*

EFFECT OF LONG TERM IMMOBILIZATION ON VOLUNTARY ACTIVATION PATTERN OF THE TRICEPS SURAE MUSCLE IN PREPUBESCENT CHILDREN: A CASE STUDY

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AIM: Very few studies related to muscle function in prepubescent children are focused on changes in muscle activation capacities. In a previous study (Grosset et al, 2008) we established references data on voluntary activation parameters and their evolution with age between 7 and 11 years. The aim of the present study is to investigate eventual changes in activation capacities and their evolution with time following an immobilization in three long-term hospitalized children.
METHODS: The triceps surae (TS) activation capacities were quantified, using a specific ergometer (Pérot and al. RBM, 1999), monthly during the long immobilisation period in three diseased children and compared to healthy age-matched children. These activation capacities were evaluated thanks to the analysis of EMG-Torque relationships. Electromyograms (EMG) were detected on each part of the TS using surface electrodes. EMGs were rectified and summed up to get the triceps surae response. The Tibialis anterior (TA) EMG was also recorded. Maximal Voluntary isometric Contraction was required three folds and the best value was taken as MVC. Then, the child maintained for 5 seconds an isometric torque at 10, 25, 50, 75 and 100% of MVC. Two-minutes rest was given after each trial. The slope of the EMG_{TS}-Torque relationship was used to obtain an index of neuromuscular efficiency. The level of TA co-contraction was estimated by the slope of the EMG_{TA}-plantar flexion torque relationship. The activation deficit (AD) was investigate using the twitch interpolated method and calculated as AD = [(torque with TI/torque before TI) - 1] * 100. The M-wave response to a supra-maximal stimulus applied to the posterior tibial nerve was recorded to normalize EMG signals.
RESULTS: The EMG-Torque relationships analyses reveal that compared with healthy children of the same age the immobilization in children leads to a lower maximal activation capacity as well as a lower neuromuscular efficiency under maximal and sub-maximal conditions. An over-activation at low torque levels, a higher co-contraction activity, and a higher activation deficit under maximal and sub-maximal conditions was also evidenced. Only the dispersion of the cloud of points, evaluated at 25% and MVC, were not affected by immobilization.
CONCLUSION: As expected regarding adult literature, an immobilization period in children also leads to an important decrease in voluntary activation capacities. The growing phase doesn't counterbalance the hospitalization effect month after month. However, the immobilization period in children was not complete due to the fact they could move without restriction in their bed. Other parameters like reflex excitability shown a contradictory evolution following hypo-activity in these children. Thus it seems difficult to conclude, regarding the weak number of immobilized children, on the adaptation mechanisms responsible for the highlighted results even though they clearly evidenced a decrease in agonist-antagonist coordination. This study shed for the first time some light into the patterns of muscle modifications following immobilization in children.

OPTIMIZING FES-ASSISTED SIT TO STAND TRANSFER INITIATION IN PARAPLEGIC INDIVIDUALS USING TRUNK MOVEMENT INFORMATION

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AIM: The aim of this article is to present preliminary results concerning the improvement of Functional Electrical Stimulation (FES)-assisted sit-to-stand transfers in paraplegic subjects. The approach is based on the coordination of upper and lower body in order to reduce the arm efforts and to decrease the stimulation intensity needed to achieve the transfers. We consider that a better synchronization between trunk movement and leg contractions should result in a less constraining sit-to-stand transfer in terms of voluntary efforts and quadriceps contraction. The proposed approach is based on the observation of trunk movement and a detection algorithm, which triggers a pre-programmed stimulation pattern. The detection algorithm has been validated for healthy subjects sit-to-stand early detection in previous publications. The application of this algorithm for FES-assisted transfers is investigated here.
METHODS: One wireless accelerometer is positioned on the trunk, at C7 level of paraplegic subjects. The detection algorithm consists in correlating the measured trunk sagittal acceleration to a reference. The detection algorithm is linked to PROSTIM© stimulator. The subject is sitting in between parallel bars. He is asked to bend the trunk forward. We record the upper limb efforts applied to the bars using 6-axis force sensors.
RESULTS: We present the setup developed to control stimulation application based on the detection algorithm. We will discuss the feasibility of triggering sit to stand transfers based on trunk movements. Preliminary results concerning arm efforts during transfer will be presented as well.
CONCLUSION: Triggering sit-to-stand transfers based on trunk observation is possible. The next step is now to evaluate the effect of a better coordination between upper and lower body on arm efforts and stimulation intensity.

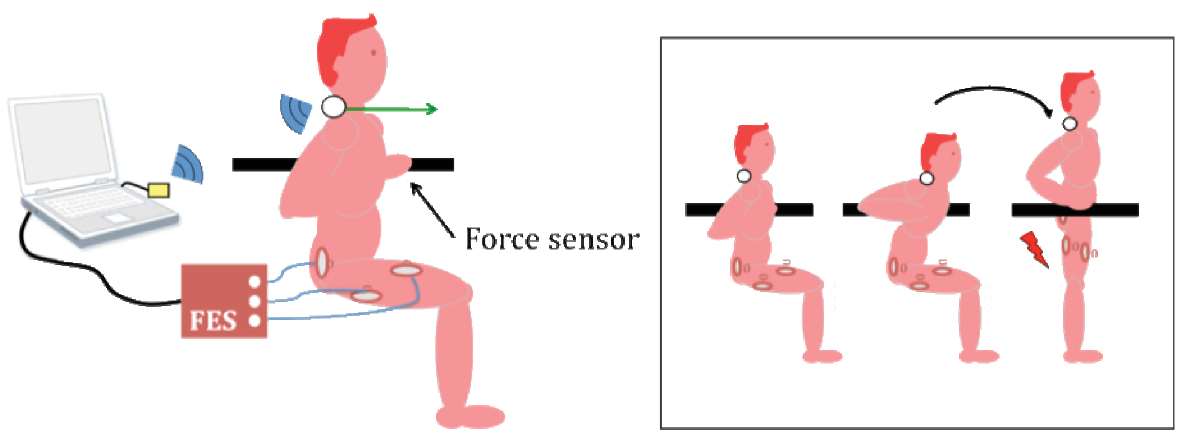

Figure 1: Protocol description

PSYCHOPHYSICAL EVALUATION OF THE EFFECT OF ELECTRODE LOCATION ON SENSATIONS DURING ELECTROCUTANEOUS STIMULATION

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AIM: Electrical stimulation can potentially be used to create sensations for use as feedback in advanced prosthetics. This study aims to evaluate the psychophysical effect of electrode location on sensations during electrocutaneous stimulation.
METHODS: 16 healthy subjects were included in the study (Aged 22-36). Five electrodes were placed around the left forearm 5 cm distant to the antecubital crease, as follows: 1) Electrode 1 (E1) over the median nerve, 2) Electrode 2 (E2) laterally adjacent to E1, 3) Electrode 3 (E3), 4 (E4), and 5 (E5) equally spaced between E2 and E1. Fixed-amplitude biphasic square pulse stimuli at three times of sensory threshold were applied through the five electrodes. Immediately following each stimulus, subjects were presented a questionnaire to score the perceived sensation types and quality. A visual analog scale (VAS) was used to measure the sensation strength.
RESULTS: All the 16 subjects reported tactile sensations (press or pulsing) at the E1 site, while fewer subjects reported tactile sensations at the E3 or the E4 site. The lowest sensation strength reported by the subjects appeared at site E4. Table 1 describes the responses of tactile sensation in detail. Based on the Friedman test, the five electrode sites show statistically significant differences in the perceived strength of tactile sensation (p=0.003). Moreover, clustering of sensation types indicated that E3 and E4 tend to evoke similar sensation types, while E1, E2 and E5 fall into another cluster (figure 1 (a)). Clustering of sensation quality gives the same cluster result (figure 1(b)).
CONCLUSION: Electrical stimulation to the different sides of the forearm evoked different responses. Stimulation of the ventral side was more likely to induce tactile sensations. Moreover, the magnitude of the perceived sensations was stronger on the ventral side compared to the dorsal side at the same level of stimulation. It seems to be more appropriate to induce sensation feedback on the ventral than the dorsal side of the forearm.

Table 1: The number of subjects who reported 'tactile' sensation, the mean of the tactile sensation strength (VAS) at the five electrode sites.

Electrode site	E1	E2	E3	E4	E5
Number of subjects	16	13	8	9	14
Mean of VAS	2.54	2.95	2.80	1.63	2.10

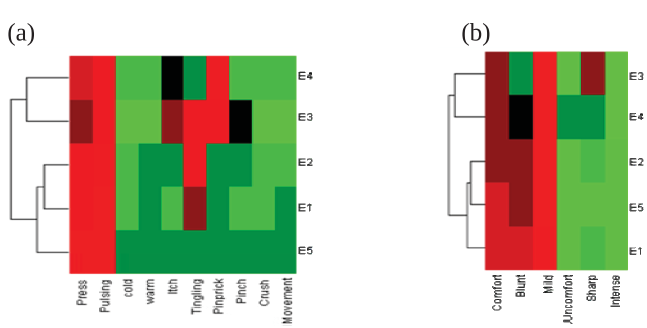

Figure 1: Clustering of the five electrode sites (16 subjects): (a) Sensation type. (b) Sensation quality.

PREDICTING FORCE LOSS DURING DYNAMIC FATIGUING EXERCISES FROM NON-LINEAR MAPPING OF FEATURES FROM THE SURFACE ELECTROMYOGRAM

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AIM: This study proposes a method for predicting force loss during isokinetic exercise of the quadriceps using a set of sEMG variables and an artificial neural network.
METHODS: Nine healthy men (age, mean ± SD, 28.0 ± 2.7 yr, body mass 74.1 ± 13.5 kg, height 177.5 ± 6.6 cm) participated in two experimental sessions separated by two days. Each session consisted of 75 maximal concentric knee extensions at $80 \cdot s^{-1}$ and 50 at $30º \cdot s^{-1}$ (both in the range 90º-170º of knee extension) performed in random order with 40 min rest in between. Force and sEMG recorded from nine locations over the quadriceps muscle were assessed. A multi-layer perceptron (MLP) neural network was trained using the mean absolute value (MAV), median frequency (Fmed) and the spectral index proposed by Dimitrov[1] (FInsm5) to map changes in force loss. The proposed method was compared with a previous approach for the assessment of fatigue (mapping index, MI, previously proposed by MacIsaac[2]) calculated from MAV, zero-crossing (ZC), rate of slope sign changes (SSC) and wavelength (WL).The data collected (at both velocities) during the first session were used to train the MLP (training set) whereas the data from the second session were used for testing the performance (test set). Performance was evaluated using a signal-to-noise (SNR) metrics computed on the estimated trend of fatigue.
RESULTS: The SNR obtained with the proposed approach was greater (8.83 ± 1.07) than that obtained with the MI (5.67 ± 1.17) ($P < 0.05$) when the subjects where analyzed individually and when the network was trained over the entire subject group (8.07 vs. 4.42).
CONCLUSION: This study showed that the loss in maximal force generation capacity of the quadriceps muscles during repetitive isokinetic knee extensions can be predicted from a set of surface EMG variables with greater accuracy than previously proposed indexes of muscle fatigue. Previous indices have assumed a linear progression of fatigue over time, whereas the decrease in maximal voluntary force (direct measure of fatigue) is rarely reported as linear. Our approach takes into account this non linear decay which may explain the greater accuracy of our method.
ACKNOWLEDGEMENT: Public University of Navarre, the Spanish Ministry of Education (National Plan of R&D+i 2004-2007. Key Action “Sport and Physical Activity” DEP2006-56076) and the Danish Council for Technology an Innovation (contract number 26-04-0176).

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ECCENTRIC & CONCENTRIC CALF MUSCLE LOADING: AN IN VIVO STUDY OF FORCE & EMG

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AIM: Achilles tendinopathy is common in sports people. [1] The main conservative treatment is heavy load eccentric training (ET) of the triceps surae, but it is unclear why eccentric and not concentric training (CT) has been shown to be effective.[2] It is likely that the whole triceps surae unit will be involved in mechanical remodelling and not just the Achilles tendon, hence the aim of our study was to compare eccentric and concentric loading modalities to investigate differences in muscle activity and tendon force (TF) across the muscles of the triceps surae.
METHODS: Twelve healthy volunteers (6 male and 6 female, mean age 27.8 ± 1.9 years (SD)) performed eccentric and concentric loading exercises for the triceps surae. Tendon force and extension were measured during each exercise, using a motion analysis system in conjunction with force plate data to determine resultant tendon forces, and ultrasound tracking of the muscle tendon junction to determine tendon length changes. A 5-7 MHz linear ultrasound probe was placed on the leg such that the medial gastrocnemius muscle–tendon junction could be imaged (Voluson e, GE Healthcare, UK). In addition, electromyography (EMG) recordings were used to determine muscle activity of the soleus, lateral gastrocnemius, medial gastrocnemius and tibialis anterior muscles. Movement was measured using the CODA CX1 motion tracking system (Charnwood Dynamics, Rothley, UK). Tendon force was calculated by dividing the ankle joint moment by the moment arm between the tendon and the ankle joint centre.
RESULTS: While some inter-subject variability was apparent, CT and ET resulted in distinctly different loading patterns and muscle activation patterns across all subjects. ET resulted in greater values for both the rate of change of tendon force, and the maximal force (1604±89N) compared with CT (1410±79N) $p < 0.01$. In contrast, when looking at EMG data both the rate of change of muscle activation and the maximal activation values were significantly higher ($p < 0.01$) in CT than ET. Pairing eccentric and concentric EMG data for each subject highlighted that, whilst the mean CT muscle activity levels were higher, the ratio of mean concentric to mean eccentric activity for each subject varied between muscles, with values of 1.08- 2 for soleus, 1.25-3.03 for lateral gastrocnemius, 1.08-1.48 for medial gastrocnemius and 0.09-1.83 for tibialis anterior.
CONCLUSION: Significant differences in EMG and tendon force were demonstrated between eccentric and concentric loading protocols that may underlie some of the differences in the therapeutic effect. The relatively low EMG activity during eccentric action was expected. The combination of the EMG and force data indicates that eccentric contractions required lower levels of voluntary activation by the nervous system to achieve a given muscle force, applied to the tendon. It may be that the associated energy preservation during ET, via ATP sparing, allows a greater volume of exercise to be carried out under eccentric conditions than concentric. Future, imminent, work will clarify group stress – strain relationships.

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MODIFICATIONS OF UPPER LIMB MUSCLE SYNERGIES IN POST-STROKE PATIENTS DURING ROBOT-MEDIATED NEURO-REHABILITATION

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AIM: Previous experiments have suggested that the CNS may coordinate muscle activations through a linear combination of muscle synergies. Neurological diseases influence motor recruitment and, consequently, modify muscular synergies. To understand the modifications induced by robot mediated neuro-rehabilitation in post stroke patients, we compare muscle synergies extracted pre and post intervention, together with those of a neurologically intact control group.
METHODS: Five patients with unilateral ischemic stroke participated at robot mediated rehabilitation therapy for upper limb. EMG activities were collected at 1500 Hz from 9-11 upper arm and shoulder muscles (Biceps BIC; Brachial BRAC; Brachioradialis BRAD; Deltoid, anterior DEL_A, medial DEL_M, and posterior DEL_P; Latissimus Dorsi LAT; Pectoralis Major PEC_M; Teres Major TER; Superior Trapezius TRAP; Triceps TRI), the first and the last day of treatment. Five healthy subjects were involved in the study as control group. Data were rectified, low-pass-filtered (Butterworth, 4th ord., 20 Hz) and normalized to a maximal values. Muscle synergies were extracted using statistic algorithm "Non-Negative Matrix Factorization"; weights and coefficients were compared between pre and post treatment and between stroke and healthy subjects using scalar product and correlation coefficients.
RESULTS: Preliminary results showed differences between muscle synergies extracted from impaired and healthy subjects. Healthy subjects present more muscles loading each synergies with a higher weight coefficients than stroke patients. However, in spite of an improved of motor performance due to the robotic aided therapy muscle synergies do not significantly differ between pre and post treatment.
CONCLUSION: The present study shows that muscle synergies are altered after a stroke event and that they are not significantly modified by rehabilitation. This behaviour could be explained as a reinforcement of residual motor strategies acquired after the stroke.
The concomitant improvement of motor performance and the absence of significant modifications of muscle synergies could lead to a greater energetic cost in post stroke patients.

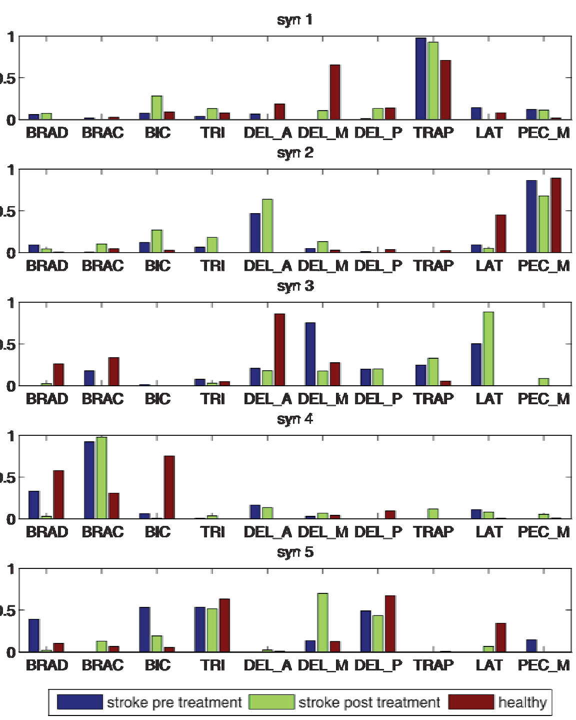

Figure 1: Representative muscle synergies for a stroke and a healthy subject.

ANALYSIS OF MUSCLE FATIGUE IN STROKE VICTIMS FOLLOWING TWO FUNCTIONAL ELECTRIC STIMULATION PROTOCOLS

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AIM: Strengthening the paretic musculature promotes improvement in functional capacity, which may be obtained through functional electrical stimulation (FES), but training and specific parameters are needed in order to avoid fatigue. With the aim of better understanding one of these electrical stimulation parameters, the purpose of the present study was to determine the appearance of muscle fatigue in individuals with hemiparesis stemming from a stroke.
METHODS: Blood samples were collected from 18 individuals with hemiparesis at seven moments: rest/pre-treatment, after each of three series of 15 stimulation repetitions and at the 3^{rd}, 6^{th} and 9^{th} minute following the end of the exercise. Analyses of muscle fatigue [median frequency (MF)] and maximal voluntary isometric contraction (MVIC) were carried out, measured by means of the load cell (Kg/force) reading of the *Biceps brachii* muscle. A biphasic square current was used, with 10 seconds of “on time”, 30 seconds of “off time” and a variable frequency of 50 Hz (Protocol 1) and 2000 Hz (Protocol 2) on the motor point of the *Biceps brachii* muscle. As all data were parametric, the Student’s t-test was used to compare mean values between the two protocols and Tukey’s DHS test for the comparison of multiple means was used in the presence of statistical significance. The level of significance was set at 5%, with an and β of 0.01.
RESULTS: No statistically significant difference was found ($p<0.05$) between Protocol 1 (1.53 ± 0.85) and 2 (1.23 ± 0.51) in lactate concentration. Analyzing the angular coefficient (AC) of the *Biceps brachii* muscle during isometric flexion of the elbow in Protocol 1, the final value of -13.78 ± 4.45 was larger than the initial value of -11.62 ± 4.58 ($p=0.21$), whereas the final and initial values in Protocol 2 were -13.17 ± 4.40 and -11.88 ± 4.47 ($p=0.44$), but these differences did not achieve statistical significance ($p<0.05$). No significant difference was recorded in the immediate post-treatment period. Based on the results from the measurements of lactacidemia, electromyography and torque, no muscle fatigue was detected in the *Biceps brachii* muscle for the two functional electrical stimulation protocols employed (50 and 2000 Hz).
CONCLUSION: Based on the results of the present study and the importance of electrical stimulation as a support to the functional improvement of patients with hemiparesis, with an increase in the range of motion, reduction in spasticity and increase in muscle strength, further studies are needed in the quest for safe protocols. Thus, continuity should be given to this study, with alterations in the muscles and functional activity elicited by electrical stimulation, along with improvements in the muscle fatigue measurement tools and detection.

EXPANDING OUR VIEW OF THE SPINE SYSTEM

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There exists a critical barrier for improving our understanding of the spine system, which stems from our static characterization of stability. Clearly for any system, including the spine, to fulfill its intended goal requires the system to be stable. For the spine, stable behavior allows it to bear loads, permits controlled movement, while avoiding injury and pain. It is a well established theory that systems require feedback control for stability. With feedback control, information about the state of the system is used to generate stabilizing control input. But what information is fed back to stabilize the system?

To answer this question, we can perform a simple experiment using stick balancing. Like the spine, a stick in the palm of the hand represents an inverted pendulum, which requires some form of control to maintain stability. In figure 1, there are two stick balancing scenarios. In the first scenario (A), the stick is positioned to the left of the hand with zero velocity. To stabilize the stick would require the hand to move to the left. In the second case (B), the stick has the same starting position, but is moving to the right. For the second scenario, which direction should the hand move to catch the stick? It is unclear and depends on how fast the stick is moving. If the stick is moving slow, you would want to move your hand to the left. But if the stick is moving really fast, to catch the stick would require moving your hand to the right. This simple experiment shows that two independent sets of data, referred to as "states", are used for feedback control. We use position-related feedback, referred to as stiffness, and velocity-related feedback, referred to as damping, to control and stabilize a system with mass. This is an important observation that has significant ramifications for how we study the spine system. Our current characterization of spine stability is based on the elastostatic approached first derived by Bermark [1]. "Elasto" stems from the elastic properties of the system. "Static" refers to the fact that the spine system is frozen in time, meaning it is stationary. Hypothetical perturbations are then applied to the spine to determine if it is stable. Using this approach, it was shown that muscles and the stiffness they provide are essential for spine stability [1]. Not surprisingly, muscle stiffness became linked with stability.

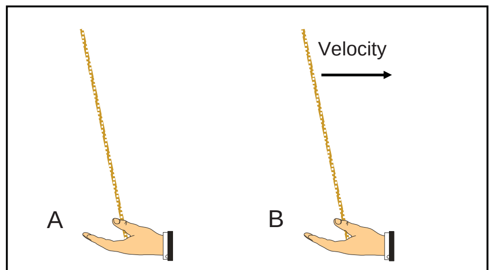

Figure 1: Stick balancing task.

To demonstrate our limited view of the spine system, we recently performed PubMed searches using the following terms: (1) "stiffness" AND "spine" AND "stability" and (2) "damping" AND "spine" AND stability". Search 1 and 2 yielded 234 and 5 hits respectively. If you exchange "stability" with "instability" similar results will be obtained. This exercise shows that we have an incomplete picture of the spine system. We need to expand our definition of stability from the current static characterization to include dynamics.

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DEVELOPMENT OF A BIOFEEDBACK CONTROLLER TO RECOVER A SYMMETRICAL PEDALING IN HEMIPARETIC PATIENTS

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AIM: This study was aimed at the development of a biofeedback (BF) controller to improve the recovery of a symmetrical pedaling in the rehabilitation of hemiparetic patients.
METHODS: A commercial motorized ergometer was equipped with an encoder to acquire the crank angle and strain gauges to measure the torques applied to the right and left pedal. A protocol was proposed: 40 s of passive cycling (the legs are moved solely by the motor), followed by voluntary pedaling aided by a visual BF. For each revolution of voluntary pedaling, the active torques were computed as the difference between the actual torques and the mean torques obtained during passive cycling. Two indexes, SI (i. e., the maximum of circular cross-correlation between right and left active torques) and SA (i.e., the angular shift in correspondence to SI), were computed. Furthermore, the works produced by each leg was obtained as the integral of the active torque and displayed to the patient through two bars. Each red bars became green when the goal was reached in terms of work. An additional panel advised the patient when the pedaling was symmetric (SI>0.85; SA<30°) with a green "OK".
RESULTS: Figure 1 shows the trends of the BF indexes during a trial performed by a patient suffering from a right hemiparesis. At the beginning of the trial, the patient pedaled mostly with the healthy leg; in fact, the left work is higher than the right one and SI and SA show a low correlation between the torques. After about 100 s of voluntary cycling, the subject was able to obtain a symmetrical pedaling, both in terms of work production and motor strategy.
CONCLUSION: The visual BF is easy to understand and motivate the patient. Moreover, the identified indexes allow a quantitative assessment of motor performance during cycling, useful also to monitor the patient progress and to compare different treatment protocols.

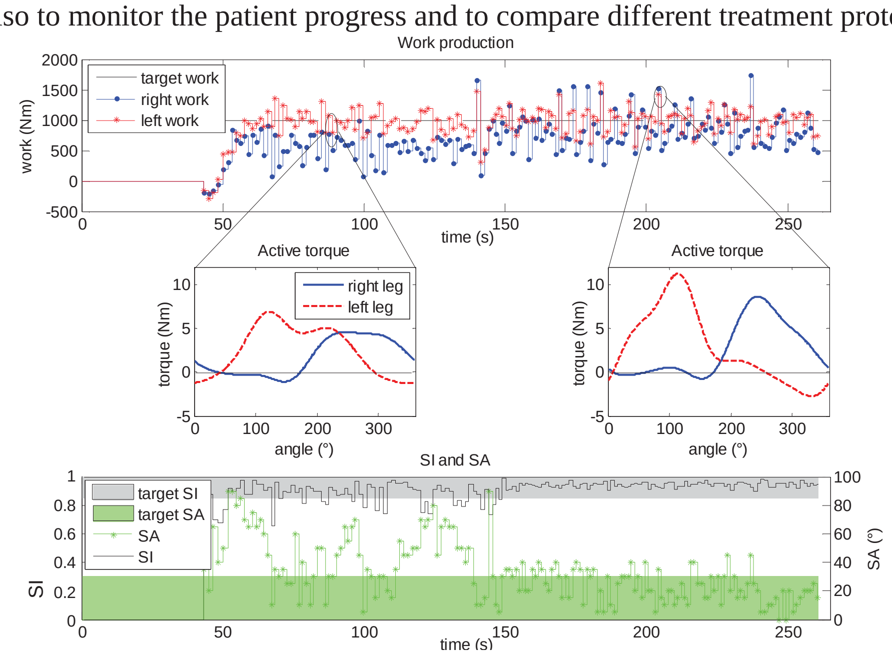

Figure 1: Results obtained by a hemiparetic patient during a trial of the BF controller.

EFFECTS OF GENERALISED JOINT HYPERMOBILITY ON KNEE FUNCTON AND MOTOR CONTROL

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AIM: To study knee function and motor control in adults and children with generalized joint hypermobility.
METHODS: Subjects with generalized joint hypermobility (GJH) (18 adults, mean age 40.1 yrs., 19 children, mean age 10.1 yrs.) and control subjects (ctrl)(18 adults, mean age 40.3 yrs., 20 children, mean age 10.2 yrs.) participated. Mobility was assessed according to the Beighton scoring (BS). The criteria for hypermobility were for the children BS≥ 5, at least one hypermobile knee and no knee arthralgia and for the adults BS ≥ 4 and at least one hypermobile knee. The subjects performed maximal as well as submaximal (25 %MVC) isometric knee extensions and flexions in a sitting position (knee angle 100° and lower limb vertical). Exerted force was measured at the ankle. Muscle strength was measured as best of three trials and normalized to body mass (Nm/kg). Submaximal torque steadiness (coefficient of variation: T_{CV}) was calculated as mean of five 15-s trials and expressed as % mean exerted torque (%T_{mean}). Relative muscle activation of the vastus lateralis (vl), vastus medialis (vm), biceps femoris (bf) and semitendinosus (st) muscles were measured with surface electromyography (EMG), calculated as EMG_{RMS} and expressed as %EMG_{max}. Co-contraction during the submaximal contractions was calculated as the antagonist EMG_{RMS} x agonist $EMG_{RMS}{}^{-1}$ x 100 (%).
RESULTS: Neither maximum knee extension torque nor knee flexion torque differs between GJH and ctrl. During the submaximal contractions, knee-extension agonist EMG (vl, vm) did not differ between GJH (20.9 %EMG_{max}, 21.5 %EMG_{max}) and ctrl (20.3 %EMG_{max}, 20.9 %EMG_{max}). However, during knee flexion agonist EMG_{RMS} (bf, st) was reduced (GJH: 24.6 %EMG_{max}, 22.8 %EMG_{max}, ctrl: 28.6 %EMG_{max}, 25.7 %EMG_{max}) and co-contraction was increased in GJH (12.8 %) compared to ctrl (9.5 %), indicating a different muscle activation pattern during submaximal knee flexions. Knee extension T_{CV} did not differ between GJH (2.8 % T_{mean}) and ctrl (2.7 % T_{mean}), but knee flexion T_{CV} was significantly higher in the adult GJH group (GJH: 3.7% T_{mean} vs. ctrl: 2.2 % T_{mean}) while no difference was found between GJH children and ctrl children (GJH 4.6% T_{mean}, ctrl: 5.2 % T_{mean}). The impaired torque steadiness in the adult GJH-group during submaximal knee flexions may be a functional consequence of reduced activity of the hamstring muscles, and thereby changed muscle activation pattern during knee flexion. In the adults, BS correlated with the T_{CV} (r= 0.44) and with co-contraction (r=0.37) during flexion, while no correlation was found between BS and muscle function for children. Lack of correlation among the children may be due to confounding factors related to the individual state of motor development.
CONCLUSION: Reduced muscle activation of the hamstring muscles in the GJH group as well as impaired steadiness in the hypermobile adults were found during submaximal knee flexions despite no effect of general joint hypermobility was found on muscle strength.

EFFECT OF PAIN ATTENTION/DISTRACTION AND PAIN-RELATED PSYCHOLOGICAL VARIABLES ON NEUROMUSCULAR RESPONSES DURING RAPID ARM FLEXION MOVEMENTS

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AIM: Abnormal (late) feedforward activation of trunk muscles (e.g. transversus abdominus or TrA), has been repeatedly substantiated in chronic low back pain (CLBP) patients using rapid arm flexion movements. The level of pain attention and the psychological profile of the patients are potential candidates to influence these abnormal neuromuscular responses. This study examined the effect of pain attention and variables related to CLBP (pain intensity, kinesiophobia, catastrophizing) on the feedforward activation of trunk muscles.
METHODS: 59 patients (30 men) with non-specific CLBP performed rapid arm flexion movements during six conditions (block-randomized; 5 trials per condition) manipulating their attention: (1) self-initiated (control) (2) self-initiated + pain recall (focused on their pain), (3) react to a light stimulus, (4) react to a light stimulus involving a 2-choice reaction (left light = left arm; right light = right arm) (5) two-digit and (6) four-digit recall. Conditions 3 to 6 involved different distraction levels. Surface electromyographic (EMG) signals were recorded on the right deltoid and bilaterally on four back muscles (at L4, L3, L1, T10 levels) and three abdominal muscles (rectus abdominis – RA, tranversus abdominis/internal oblique - TrA/IO, external oblique - EO). 3D angular kinematics of the right upper arm and lumbar spine was also measured with inertial sensors. Between-group comparisons were carried out with patients divided in subgroups (high and low scores) based on a median split of scores on pain intensity (10-cm visual analog scale – VAS), fear of movement (Tampa scale of kinesiophobia – TSK), or pain catastrophizing (Pain catastrophizing scale – PCS).
RESULTS: The upper-arm kinematics (angular position and velocity) was comparable ($P > 0.05$) across the different patient subgroups and between the six conditions. Feedforward activation of trunk muscles (relative to right deltoid) was not influenced by focusing attention to pain (condition 2). Among the distraction conditions, the responses were delayed (20-35 ms) for some muscles (L5 right, L1 and T10 left; TrA/IO left) but only in condition 4 (2-choice reaction) relative to conditions 1 and 2. Between-group differences were obtained (n = five cases), involving different subgroups (VAS,TSK, PCS) and muscles (L5 right and left, RA, EO and TrA/IO left), the subgroups having the lowest scores always showing delayed activity (16-29 ms) relative to subgroups having higher scores. Lumbar maximal flexion following the perturbation ($3.5 \pm 2.4°$) was not affected by the independent variables.
CONCLUSION: Pain-related variables (VAS, TSK, PCS) and pain attention did not affect the task performance (kinematics analyses). EMG results suggest that a part of the delayed feedforward activity previously shown in CLBP patients might be partly explained by attentional disruption. However, it appears that the distraction must be strong enough to have an effect (significant only for the more complex distraction condition). The between-group differences were unexpected and remain to be explained.
ACKNOWLEDGEMENTS: Co-funded by the REPAR-FRSQ and IRSST.

KINEMATIC ANALYSIS OF ONE LEG HOP– A LONG TERM FOLLOW UP AFTER ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION

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AIM: Despite reconstruction many subjects with injury to the anterior cruciate ligament (ACL) do not fully restore the knee function; i.e., muscle strength and coordination as well as kinesthesia may be impaired. This study is a long term follow up of subjects with ACL injury about 20-25 years after ACL rupture and surgical reconstruction. The aim was to describe possible compensatory strategies during One Leg Hop, which is a maximal distance jump and a common functional test of the knee in ACL rehabilitation. This jump requires explosive muscle strength, knee stability, balance and confidence in the capacity of the knee.
METHODS: This is an ongoing study and so far 20 subjects have been tested, 11 men and 9 women, (age 46 ±5.6 years, BMI 26.3 ± 2.8) all with a unilateral ACL-injury. The subjects injured their knee on average 24 ±3.3 years ago and underwent reconstructive surgery 3,8±2,9 years after injury. The subjects performed three One Leg Hops on the injured leg and the non-injured leg, respectively. The kinematics of the One Leg Hop was analysed using a 3-dimensional motion analysis system (Oqus®, Qualisys Gothenburg, Sweden) with eight high speed cameras (240Hz). The One Leg Hop was performed without shoes and with the arms across the chest. The maximum hop length was determined and Leg Symmetry Index (LSI) calculated as the ratio between the injured and non-injured leg. For the longest hop, the peak angles in foot, knee and hip were derived during a time window 1) before jump off and 2) after landing.
RESULTS: Preliminary data show a significantly shorter jump length for the ACL injured leg as compared to the non-injured leg (p=0.037; Wilcoxon); mean length for the injured leg was 1,13± 0,3m and non injured leg 1,18± 0,3m. The LSI was on average 96±10%. However, preliminary analysis indicate no differences in peak angles for foot, knee or hip between the injured and the non-injured leg measured before jump-off and after landing. On-going analysis will further explore the kinematic quantification and details of the jump.
CONCLUSION: In general, subjects with reconstructed ACL show rather good performance in their injured leg compared to the non-injured almost 25 years after injury, which is reflected by the relatively high LSI and the absence of clear differences in kinematics.

BACK MUSCLES SPECIFICITY OF ROMAN CHAIR ENDURANCE EXERCISES

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AIM: Excessive fatigability of lumbar paraspinal muscles is a predictor of a first episode of low back pain and a predictor of long-term back-related disability. Roman chair exercises are popular to improve back muscle endurance but does not specifically target back muscles. The purpose of this study was to determine whether an adaptation of the roman chair exercise, as tested earlier [1], would induce more fatigue in back muscles than in hip extensors.
METHODS: 16 healthy and 18 patients with non-specific CLBP performed trunk flexion-extension cycles until exhaustion, in a roman chair with hips flexed at 40° (Figure 1). Surface electromyographic (EMG) signals were recorded bilaterally on four back muscles (at L4, L3, L1, T10 vertebral levels) and two hip extensors (gluteus maximus - GM, biceps femoris - BF). The EMG signals obtained during the extension portion of each cycle for the trunk angles ranging from 30° to 10° of flexion were processed to obtain the instantaneous median frequency (IMF) and root mean square (RMS) amplitude values. The normalized slopes of IMF and RMS time-series were retained as EMG indices of fatigue. Motion analysis of the trunk segments (pelvis, lumbar and thoracic spines; Figure 1) was also carried out with accelerometers.
RESULTS: In both groups, EMG indices disclosed clear evidence of muscle fatigue for GM, less clear evidence of fatigue for lower back muscles (electrode sites at L4, L3 and L1) and motor unit recruitment (without fatigue) for upper back muscles (T10) and BF. A change of muscle activation pattern was emphasized throughout the exercise bout with back muscles at L4 and L1 showing an increase followed by a decrease or leveling off of activation and back muscles at T10 showing an increased activation only at the end. Kinematics analyses revealed a progressive decrease (11°) of the lumbar range of motion (ROM) and a progressive increase of hip (2°) and thoracic (7°) ROM over the exercise bout.
CONCLUSION: Roman chair exercises are not as specific as some more sophisticated machines having a pin loaded weight stack to fatigue back muscles relative to hip extensors, as substantiated in another study with the same subjects and measurement techniques [2]. Roman chairs allows more freedom to change the kinematics of the spine during the exercise (less lumbar and more thoracic motion) so as to delay lower back muscles fatigue by sharing the load from lower (e.g. at L4 and L1 electrode sites) to upper back muscles (at T10).

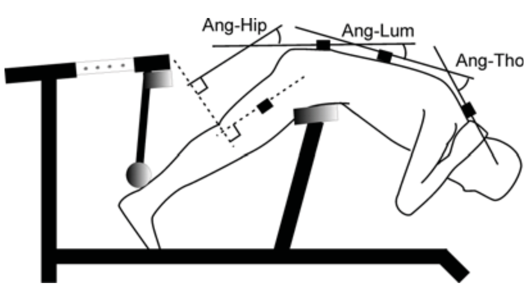

Figure 1: Definition of angles

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SURGICAL PLANNING USING MULTISEGMENT FOOT KINEMATIC DATA

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AIM: Using a case study analysis, our goal was to examine whether multisegment foot kinematic data aids in surgical planning and treatment evaluation for foot/ankle disorders.
METHODS: A 40 year old post-stroke male subject (height = 68”, weight = 76.8 kg) participated in a pre- and post-surgical gait analysis. Prior to the gait analysis, the patient’s gait was characterized as hemiparetic with a stiff-knee pattern, a fixed flexion deformity of the toe flexors, and a hindfoot varus. We used an eight-camera Vicon MCam system (Oxford Metrics Group Inc.) to capture the three-dimensional trajectories of 17 reflective markers placed on the foot and tibia (Figure 1). Motion data was sampled at a frequency of 120 Hz. The foot was assumed to consist of the following rigid body segments: a) the shank (including the tibia and fibula), b) the rearfoot (including the calcaneus and talus), c) the forefoot (including the metatarsus and phalanges), d) the midfoot (including the navicular, cuboid, and cuneiforms), and e) the foot (including the rearfoot, midfoot, and forefoot). Using the 3D marker locations, embedded coordinate systems were creating at the knee joint, ankle joint, and at each foot segment. Joint angles were computed from the relative orientations of the embedded coordinate systems using Euler angles in a yxz sequence, corresponding to flexion/extension, adduction/abduction, and internal/external rotation. Displacement data were filtered using a 6 Hz low-pass Butterworth filter. All data were normalized to 100% of the gait cycle. Temporal-spatial measures were computed for each gait cycle using the Vicon motion capture data.
RESULTS: Based on clinical exams and radiographs (prior to gait analysis), the surgical treatment plan was established and consisted of correction of the forefoot deformities, possible hamstrings lengthening, and tendon transfer of the posterior tibial tendon to the dorsolateral foot. Pre-surgical analysis of the multisegment data revealed a forefoot driven hindfoot varus. The identification of the forefoot as the cause of the hindfoot varus suggested that the tendon transfer procedure was unnecessary and was consequently removed from the surgical plan. A second gait analysis was conducted 6 weeks post surgery, shortly after cast removal. Post-surgical gait data showed improved foot segment orientation and position.
CONCLUSION: Motion capture data provides clinicians with detailed information on the multisegment kinematics of foot motion before and after surgery. This information can result in modifications to treatment plans and an improved understanding of treatment effectiveness.

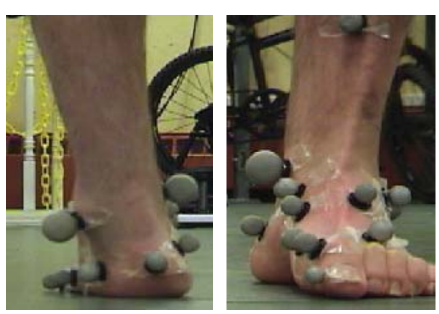

Figure 1: Hindfoot varus position of patient

INFLUENCE OF AGE ON MUSCULAR ACTIVITY DURING ISOMETRIC CONTRACTION OF VASTUS LATERALIS MUSCLE - ANALYSIS OF MECHANOMYOGRAM AND ELECTROMYOGRAM -

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AIM: It is necessary to configure the training program with careful consideration of muscular function when the elderly people having muscular weakness perform resistance training. The aim of study is to elucidate the difference of muscular activity by aging with the use of mechanomyogram (MMG) and electromyogram (EMG).
METHODS: Fourteen elderly volunteers aged 77.1±6.0 and five young volunteers aged 27.2±4.5, participated in this study. The volunteer was seated in a chair and knee joint angle of dominant foot was fixed at 60-degrees. EMG and MMG signals were measured on vastus lateralis muscle during brief isometric contraction at 50% MVC. The surface EMG signal was detected by the bipolar Ag/AgCl electrodes (5mm pick-up diameter, 20 mm inter-electrode) and the MMG signal was detected by the piezo-electric accelerometer with weight of 2g. The total power (TP) and median frequency (MDF) were computed from both signals. All data were given as mean ± standard deviation (SD) for each group subjects. A student's t-test was used to determine difference between two groups of elderly and young peoples.
RESULTS: The significant difference of MVC during knee extension was recognized between the elderly people (512.1±173.7 N) and young people (699.7±66.7 N) at significant level of 5%. For MMG, the variables of TP and MDF of elderly people were lower than those of young people (Fig.1). In particular, significant difference was recognized between two groups ($p<0.01$) in the MDF. For EMG, the variables did not differ between two groups. In the power spectrum of MMG, spectrum of elderly people only had one peak of 10Hz although spectrum of young people had two peaks of 10Hz and 40Hz.
CONCLUSION: In this study, the results were obtained as the following. (1) TP and MDF of MMG were influenced by age although both variables of EMG were not influenced by one. (2) For elderly people, the power spectrum of MMG did not have high frequency component of 40Hz. These results might be related to the muscular atrophy and the decreasing of fast muscle fiber by aging.
ACKNOWLEDGEMENT: This work was supported by Grant-in-Aid for Young Scientist (No. 19700468).

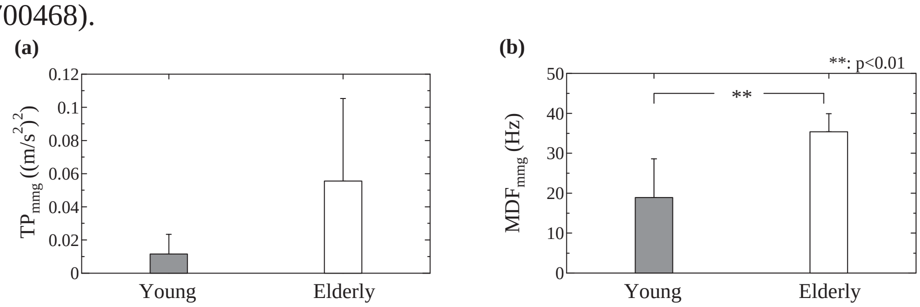

Figure 1: Comparison of total power: TP (a) and median frequency: MDF (b) between elderly people and young people during voluntary isometric contraction of vastus lateralis muscle.

NECK EXTENSION/FLEXION RATIO IN F-16 PILOTS: EFFECTS OF TRAINING

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AIM: With the implementation of Helmet Mounted Cuing Sights F-16 pilots get information projected on the inside of their visor and not any longer in front of them on a head up display. This is an operative advantage but the helmet and sights are getting increasingly heavy and big loads are applied on the pilots' neck. At 9Gz the load can get as high as 55-60kg and is often applied with a rapid onset. Having made it possible to look around without losing essential information the neck is more frequently positioned away from anatomical neutral position. Several studies have shown that around 90-96% of fighter pilots' complain about neck pain. Our aim was to explore the Maximal Voluntary Contraction (MVC) and Rate of Force Development (RFD) for neck extension and flexion and through individually planned neck training optimize the ratio towards a ratio around 1.7 which is considered normal for humans. The training consisted of static pull in both straight and oblique directions.
METHODS: The study was carried out as a randomized controlled trial. After baseline measurements 55 pilots were randomized to either 24 weeks of neck training 3x20 minutes a week (n=27) or control (n=28). If extension/flexion ratio was smaller than 1.4 or bigger than 2.0 (average 1.7) the pilot received static training considering his weakest direction by pulling less weight in his strongest direction. Measurements of neck extensor and neck flexor MVC and RFD were carried out at baseline and after the 24 weeks intervention period.
RESULTS: The overall extension/flexion ratio at baseline was on average1.7 but with very large variation between pilots, range: 1.03-2.79. After training the average ratio in both groups remained unchanged but the inter-individual variance became smaller in the training group range: 1.15 - 2.37 (F-test: 0.08), but remained unchanged in the control group, range: 0.92 - 3.28 (F-test: 0.42). Neck flexor MVC was increased significantly in both groups. In the training group from 187 N to 203 N (p=0.02) and in the control group from164 N to182 N (p=0.007). Neck extensor MVC improved significantly in the control group from 270 N to 291 N (p=0.02) and a corresponding trend was seen in the training group from 292 N to 310 N (p=0.1). RFD for neck flexion was significantly improved in the training group from 880 N/s to 1000 N/s (p=0.03) but not in the control group (810 N/s to 850 N/s, p=0.6). RFD for neck extension increased from ~ 1400 N/s with 14% in both groups, but was significant in the control group only.
CONCLUSION: Even though all pilots in the training group were trained, the primary goal in this group was to correct neck extension/flexion ratio towards 1.7 by correcting pilots having a ratio outside a ratio interval of 1.4-2.0 as this interval is considered "normal". 13 out of the 27 pilots in the training group needed correction. 6 pilots' were relatively weak in flexion and 7 pilots in extension, but the first mentioned 6 pilots were further away from the desired range, and all in all flexion was trained more intensively. Thereby neck MVC for flexion was improved most. Many pilots did not train enough and even though static neck exercises were part of all sessions, we consider it possible to move neck extension/flexion ratio for the individual pilot significant. Neck RFD was increased in both groups and the pilots comment on this by emphasizing that they complied better with the test the second time they carried it out.

SELECTIVE ACTIVATION OF NEUROMUSCULAR COMPARTMENTS WITHIN THE HUMAN TRAPEZIUS MUSCLE IN PATIENTS WITH SHOULDER PAIN COMPARED TO CONTROLS

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AIM: Abnormal scapular positioning and muscle coordination has shown an association with shoulder impingement, and is therefore a key aspect in rehabilitation. An impaired scapula coordination of subjects with impingement could be due to a reduced ability to selectively activate the lower parts of the trapezius as a main stabilizer of the scapula. Biofeedback has been found usable to support an independent activation of specifically the lower subdivisions of the trapezius muscle in a healthy population. Therefore, the aim of this study was to test the ability to biofeedback guided selective activation of the subdivisions of the trapezius muscle in subjects diagnosed with impingement compared to healthy subjects.
METHODS: Thirty subjects volunteered, 15 subjects with impingement syndrome (*imp*) (7 males, 8 females, 40 yrs ± 13) and 15 healthy subjects (*no-imp*) (7 males, 8 females, 39 yrs ± 12). Inclusion criteria for *imp* were at least 30 days with pain/discomfort in the shoulder/neck region within the last year and 2 or more positive impingement tests, while for *no-imp* it was less than 8 days with pain/discomfort in the same area within the last year and no positive impingement tests. A strict protocol containing six selective activation tasks each lasting three min. was conducted. With the subjects supine, surface electromyographic signals (EMG) were measured from the four subdivisions of the trapezius muscle and used for source of visual biofeedback. Maximal EMG amplitude (MVE) was measured for each subdivision. Selective activation was defined in two ways; First as activity in the requested subdivision above 12% and the others below 1.5% MVE. Secondly, based on activation ratio; the summed activity of the requested subdivisions calculated relative to the sum of activation in all 4 subdivisions in 1 sec windows. For each task the 1 sec peak value was recorded and a positive result was obtained when value exceeded 95 % of the summed activation. An unpaired t-test was applied to test differences between groups.
RESULTS: During a 3 min biofeedback session, 8 (27%) *imp* vs. 8 (27%) *no-imp* attained selective activation of the lower subdivisions based on definition 1. In contrast, only 1 *imp* subject vs. 1 *no-imp* subject was able to selectively activate the two upper subdivisions. Regarding activation ratio, 12 *imp* (55%) vs. 10 *no-imp* (45%), produced an activation ratio higher than 95% of the lower subdivisions while for the upper subdivision this was the case for and 1 *imp* vs. 1 *no-imp*. There was no difference in lower subdivisions mean peak values of *imp* and *no-imp* (95,6% SD 5,6 vs. 96,4%; SD 2,8 (p=0,647)), respectively, nor for the upper subdivisions 85,7%; SD 8,0 vs. 85,3%; SD 13,0 (p=0,922)), respectively .
CONCLUSION: Most interestingly, there was no difference between *imp* and *no-imp* regarding the ability to selective activation. However these findings show that it is feasible to use biofeedback to increase selective activation of the lower subdivisions of the trapezius muscle thereby improving scapular coordination also in individuals with impingement syndrome
ACKNOWLEDGEMENT: This study was supported by the National Research Fund for Health and Disease, the Research Fund for the Region of Southern Denmark, and The Arthritis Research Association.

DIFFERENTIAL EFFECTS OF JOINT ANGLE AND FATIGUE ON VOLITIONAL AND MAGNETICALLY-EVOKED NEUROMUSCULAR PERFORMANCE

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AIM: Optimal functioning of skeletal muscle is considered fundamental to the capability for stabilisation of synovial joints and prevention of musculoskeletal injury, particularly at extended joint positions that correspond to positions of vulnerability and joint injury. The purpose of this study was to examine the fatigue-related volitional and magnetically-evoked neuromuscular performance of the knee extensors at three functional joint angles (25°; 30°; 45° knee flexion).
METHODS: Indices of knee-extensor volitional and magnetically-evoked neuromuscular performance (N= 7 healthy males; 24.0 ± 2.8 years; 70.3 ± 4.5 kg; 176.2 ± 5.9 cm) were obtained at 3 joint angles (25°; 35° and 45° knee flexion; 0° = full extension) prior to and following an acute fatiguing task (4 episodes of 3 x 10s maximal voluntary static activations) and a control condition of equivalent duration consisting of no exercise. The control condition was performed first on each assessment occasion and the presentation of joint angle was randomised over three (non-consecutive) days.
RESULTS: A significant 3-factor interaction associated with the repeated measures ANOVA ($F_{[2,12]} = 4.8$, $p < 0.05$) revealed that the fatigue task was associated with an impairment to volitional peak force (PF_V) that was larger at positions of greater knee flexion (10.0%; 14.2%; 20.9%, at 25°; 35° and 45°, respectively). A significant 2-factor (condition x time) interaction ($F_{[1,6]} = 11.4$, $p < 0.05$) showed that the volitional electromechanical delay (EMD_V) of the vastus lateralis was significantly impaired by the fatigue task by similar amounts at each joint position (group mean impairment of ~12%). A significant 3-factor interaction ($F_{[2,12]} = 5.1$ $p < 0.05$) associated with magnetically-evoked peak twitch force (P_TF_E) data revealed an improvement to performance following the fatigue trial that was dependent on joint angle; the least amount of improvement was observed at the most flexed joint position (38%; 56%; 19% improvements at 25°; 35° and 45°, respectively). No significant or main effects were revealed for magnetically-evoked electromechanical delay (EMD_E) of the vastus lateralis, suggesting that this index of performance remained largely unaffected by joint position and by the fatigue intervention.
CONCLUSION: The current data confirms that muscles may be at a greater susceptibility to fatigue at longer lengths, corresponding to positions of greater joint flexion in the current study. The similarity of impairment to EMD_V across joint angles, may reflect differential contributions of contractile and elastic factors at these positions during conditions of fatigue. Given that injuries occur in short time periods, such impairments to thigh muscle performance may negatively impact the capability for rapid dynamic joint stability in response to unpredictable loading of the knee by broadly similar amounts at these joint angles. The concomitant preservation (EMD_E) and potentiation (P_TF_E) of indices of evoked neuromuscular performance, however, may suggest a vital facilitatory mechanism to overcome these impairments, and a more efficient neuromuscular response over a functional range of joint positions that can be deployed during critical times to protect the joint system.

BALANCING AN UNSTABLE LOAD WITH PRONO-SUPINATION MOVEMENTS OF THE WRIST: FEASIBILITY STUDY WITH A WRIST-ROBOT

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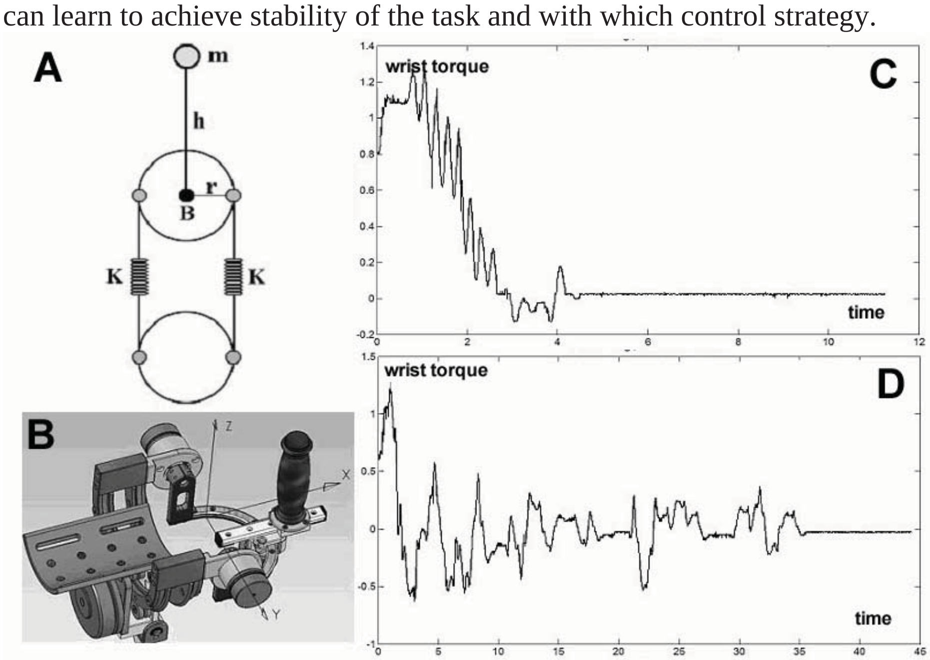
AIM: Recent studies demonstrated that virtual reality, if combined with robot therapy, can be an effective tool in the rehabilitation of stroke patients, with emphasis on tasks of increasing complexity that address the residual sensorimotor capabilities of the patients and the intrinsic plasticity of the nervous system. An interesting but scarcely studied class of tasks involves the control of unstable loads. In this paper we present preliminary results with a visuo-haptic virtual reality system related to prono-supination movements of the wrist.
METHODS: Panel A of the figure shows the virtual load (an inverted pendulum), linked to the wrist robot (panel B) by means of two virtual springs of stiffness *K*. The rate of growth of the toppling torque is characterized by the parameter *mgh*, which plays the role of a negative stiffness. The tendency to fall is counteracted by the restoring torque generated by the robot-spring system, which provides a stiffness equal to $2Kr^2$. Two conditions can occur, according to the relative values of the two parameters: 1) $2Kr^2 > mgh$, which implies the asymptotic stability of the task (stiffness control strategy); 2) $2Kr^2 < mgh$, which means that the load is unstable and requires active stabilization.
RESULTS: Panel C of the figure shows the time course of the wrist torque for bringing the pendulum from the initial out-of-balance state to the equilibrium state, in condition 1. It shows that after an oscillatory transient the subject is able to reach equilibrium and keeping it in a stable way. Panel D shows the time course of the same variable in condition 2: the subject is still able to stabilize the inverted pendulum but it uses an intermittent control strategy.
CONCLUSION: In future experiments we shall investigate to which extent stroke patients can learn to achieve stability of the task and with which control strategy.



SPECTRAL ANALYSIS TO QUANTIFY SEGMENTAL ACCELERATIONS DURING BAREFOOT AND SHOD WALKING

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AIM: Spectral Analysis (PSD) is an alternative technique to traditional time-domain acceleration measures. It has been shown to demonstrate two distinct peaks representing kinematic-induced (active, 4-8Hz) and impact-related accelerations (12-25Hz) during running. Our aim is to quantify the active power of the spectra recorded at the shank during barefoot and shod walking and correlate this with kinematic data.
METHODS: 16 subjects (9 female and 7 male) performed five trials in barefoot and control shoe (Shore 55C, EVA 0.39) conditions. Resonant walking speed of each subject was identified in the control shoe. A tri-axial accelerometer positioned at the inferior-medial aspect of the right shank and two electrogoniometers positioned at the knee and the rear-foot were sampled at 500Hz. Acceleration data were band-pass filtered (6-50Hz) and PSD extracted and normalised. Second derivatives of knee flexion (KF) and ankle plantarflexion (PF) were extracted and used to correlate with the shank active PSD. The cross correlation coefficient technique (CCC) discriminated temporal differences in knee and ankle displacement between conditions. A paired two sample t-test identified significant differences ($p < 0.05$).
RESULTS: Active PSD was significantly greater ($p = 0.000$) during barefoot walking (mean ± sem: 0.287 ± 0.032 $g^2.Hz^{-1}$) compared to the shod condition (0.141 ± 0.023 $g^2.Hz^{-1}$). Impact PSD equated to 44.7 ± 6.4% and 64.4 ± 4.7% of total shank PSD respectively ($p = 0.001$). Moreover, impact frequency was significantly greater ($p = 0.009$) during barefoot (21.6 ± 1.1 Hz) when compared to shod (17.0 ± 1.0 Hz). CCC revealed a significantly earlier phase shift in barefoot walking at the knee during loading (0.62 ± 0.37 %stance; range: 0.94 to 1.00) and mid-stance (1.52 ± 0.59 %stance; range: 0.89 to 1.00) phases. However, the strongest correlation between active PSD and kinematics existed for ankle PF acceleration ($r = 0.80$). Indeed, barefoot PF acceleration was significantly reduced (-9.51 ± 1.05 $rads.s^{-2}$) compared to the control shoe (-18.75 ± 0.99 $rads.s^{-2}$) ($p = 0.000$).
CONCLUSION: There appears a pre-tuning effect in the barefoot condition through alterations in knee flexion prior to heel-strike and through mid-stance of the gait cycle. However the response to impact appears to be determined by ankle kinematics. We have shown that lower sagittal ankle acceleration results in increased active PSD. The mechanism(s) underpinning this is not yet clear; however, it would suggest that an increase in muscular force would be required if a concomitant reduction velocity is evident. Future work will investigate the electromyographic response between barefoot and shod conditions to further our understanding of the significance of the active power portion of acceleration spectra.

CHANGES IN EMG COHERENCE BETWEEN ELBOW FLEXOR MUSCLES DURING SUSTAINED FATIGUING CONTRACTION

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AIM: The aim of this study was to examine coherence between surface electromyographic (EMG) signals from the biceps brachii (BB) and brachioradialis (BR) muscles during sustained fatiguing isometric contraction.
METHODS: The experiment was performed on fifteen right-hand dominant healthy individuals. Bipolar surface EMG signals were recorded from the BB and BR muscles during isometric voluntary elbow flexion. The EMG data was sampled at 1.25 kHz and force at 50 Hz. Maximum voluntary contraction (MVC) was first recorded for each subject. Subjects then performed a sustained fatiguing contraction at 30% MVC until task failure. Wavelet coherence between the EMG signals was estimated during the fatiguing contraction and the sum of the significant coherence was analyzed in the tremor (7-12 Hz), beta (15-35 Hz) and gamma (35-60 Hz) bands. The magnitude squared coherence between the EMG signals during the first and second half of the fatiguing contraction was then examined. Changes in the sum of coherence values that lay above the 95% significance level in each of the frequency bands during the fatiguing contractions were estimated.
RESULTS: Coherence between the BB and BR EMG signals was observed at the frequency of physiological tremor (8-12 Hz) and within a broadband from approximately 20-60 Hz. The sum of the significant wavelet coherence showed a progressive increase during the contraction in the tremor and beta bands, Figure 1(a). A significant increase in EMG coherence was also observed between the first half and second half of the fatiguing contractions in the tremor and beta bands, Figure 1(b).
CONCLUSION: Coherence between EMG signals from the BB and BR muscles was significantly increased in the tremor and beta bands during sustained fatiguing contraction. This increased coherence with fatigue may reflect changes in motor-unit synchronization across muscles due to an increased contribution of common motoneuron inputs from peripheral afferents, spinal interneurons or corticomuscular coupling.

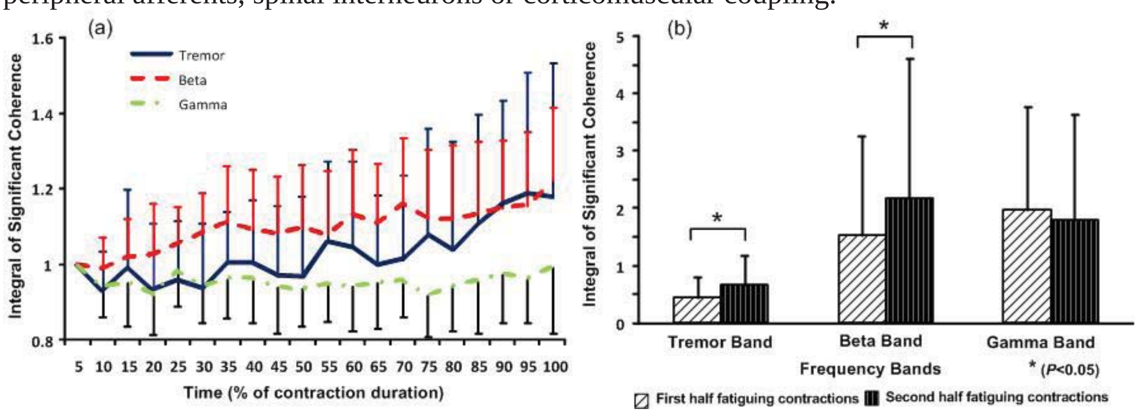

Figure 1: (a) Sum of the significant wavelet coherence in the tremor, beta and gamma bands between the BB and BR EMG signals during sustained fatiguing contraction, (b) sum of the significant coherence during the first and second half of the fatiguing contraction. The data has been averaged (mean ± SD) over all subjects.

PATHOLOGICAL TREMOR ATTENUATION USING FES-CONTROLLED JOINT IMPEDANCE MODULATION

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AIM: The main goal of this work is to evaluate the use of surface Functional Electrical Stimulation (FES) in the active compensation of pathological tremor on the upper limbs. We are particularly interested in using FES to modulate the impedance of the joint affected by tremor motion in order to attenuate the effects of the pathological motion.
METHODS: The experimental system used in the present work is illustrated on Fig. 1. Inertial sensors are used to measure the total joint motion, which is composed by tremor and voluntary motion components. Once the instantaneous tremor intensity is estimated online from this information, the appropriate stimulation parameters are computed and transmitted to the stimulator. A pair of antagonist muscle acting on the trembling joint is controlled by the FES system, in order to provide increased stability to the joint with minimum effect on the voluntary motion.
RESULTS: To date, the proposed technology has been evaluated with two different approaches. Firstly, the complete method has been evaluated in simulation with a detailed musculoskeletal model of the wrist joint. With respect to experimental evaluation, online tremor characterization methods have been successfully validated with tremor patients with different pathologies. Furthermore, the complete setup has already been tested on healthy subjects under the effects of an induced tremor controlled by an independent stimulator.
CONCLUSION: This study has demonstrated the feasibility of applying FES to attenuate the effects of pathological tremor, which is the most common involuntary motion in human pathology. Future activities will focus on additional clinical evaluation with tremor patients and the development of alternative stimulation patterns in order to handle pathological motions with increasing levels of complexity.
ACKNOWLEDGEMENT: French National Research Agency

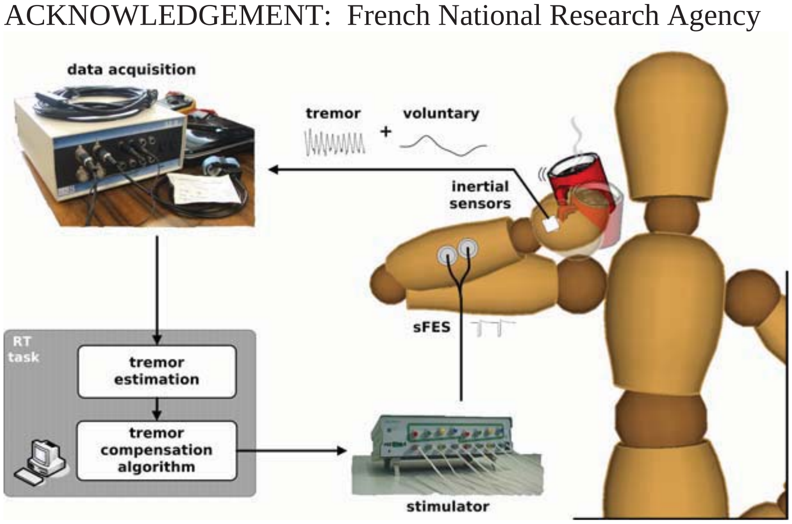

Figure 1: Experimental setup.

CHANGES IN NEUROMUSCULAR FUNCTION INDUCED BY ECCENTRIC EXERCISE: EFFECT OF ANTIOXIDANT SUPPLEMENTATION

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AIM: To determine whether the effects of exercise-induced muscle damage on neuromuscular function during submaximal knee extension exercise could be attenuated by consumption of Montmorency cherry juice (CherryActive®) rich in antioxidants.
METHODS: 10 well-trained male athletes (28±1.6y, 81±4.0kg, 176±3.0cm, single leg one repetition maximum (1RM), 73±4.0kg) completed two trials (CherryActive®, CA or isoenergetic fruit concentrate, P) of 10 sets of 10 single leg knee extensions at 80% 1RM. Participants consumed each supplement for 7 d prior to and 48h after exercise. Knee extension maximum voluntary contractions (MVC) were performed pre, 24 and 48h after the damaging exercise and were preceded by submaximal exercise (5 sets of 5 knee extension repetitions at 50% 1RM). Venous blood samples were collected at each time point and serum analyzed for creatine kinase activity. The contraction force was recorded in parallel with surface EMG from rectus femoris (RF) and vastus lateralis (VL) muscles from which EMG RMS amplitude and novel spectral EMG fatigue indices (FI) were calculated. Repeated measures ANOVA were used for statistical analysis of the data.
RESULTS: MVC force recovery was significantly faster (24h: 90.9 ± 4.2, CA vs 84.9 ± 3.4, P; 48h: 92.9±3.3, CA vs 88.5±2.9, P; % of initial MVC; P<0.05) and eccentric peak power (24h: 24.1±22.5%; 48h: 14.3±10.3%) during submaximal exercise tended to be higher during CA than P trials. Serum creatine kinase activity increased significantly from baseline peaking 24h after exercise (127±54%, P vs 108±56%, CA; P<0.05) but there was no difference between trials. EMG RMS amplitude during the eccentric phase of submaximal exercise increased across days from PRE values peaking after 24h recovery (RF: 25.2±14.3%, 24h, 3.3±11.1%, 48h, P<0.004; VL: 70.2±11.1%, 24h, 30.9±12.9%, 48h, main effect of day P=0.012) although this effect tended to be attenuated in the CA trial in VL (day vs condition interaction effect, P=0.085). A similar pattern of change across days was observed for the FI data (RF: 56.2±21.6%, 24h, -9.2±16.3%, 48h, P=0.059; VL: 49.9±38.0%, 24h, 74.2±46.3%, 48h, main effect of day P>0.05) although this effect was attenuated in the CA trial only in RF (day versus condition interaction effect, P=0.049).
CONCLUSION: After exercise-induced muscle damage stronger neural input was required to achieve the same force output, and muscle fatigability was enhanced during submaximal contractions, presumably reflective of both peripheral and neural adaptations to muscle damage. Despite the apparently similar levels of muscle damage, CherryActive® supplementation improved the recovery of isometric muscle strength perhaps due to attenuation of the neuromuscular changes induced by the damaging exercise.

A NEW ALGORITHM OF THE APS CLASSIFICATION FROM MULTICHANNEL EMG SIGNALS

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AIM: The paper presents a decomposition algorithm of the surface multichannel EMG signal. The particular steps of the proposed algorithm are presented on Fig.1a. The algorithm is based on k-means classification method. As a feature vector the coefficients of a discreet wavelet transform at level 6 were chosen. To validate the classification results the “silhouette” index was used.
METHODS: To test the algorithm the generator of the synthetic multichannel EMG signal have been designed. This signal for 4 MUs discharges modeled is presented on Fig.1b. Signal realization was divided into two parts: without overlaping APs and with overlap present.
RESULTS: Decomposition results are presented in Table 1 , Fig.1.c and Fig.1.d. It can be seen that if MUAPs do not superimpose (0-0.25s) the algorithm allows to detect and identify efficiently discharge patterns of a particular MU. In situation, where MUAPs superimpose (0.25s-0.75s) the number misclassified APs increases, but after rejecting those APs with small silhouette value from particular classes, it is possible to identify discharge patterns of nonsuperimposed MUs visible in the range 0.25s-0.75s.
CONCLUSION: The proposed algorithm with selected feature vector and k-means classification method used, can be applied to decompose signals while discharged MUs do not overlap, which is the case for example in a weak contraction of the selected muscle.

Table 1: Percentage of MUAPs of the particular MUs asigned to the particular class.

Time range	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6
0s-0.25s	**MUA:** 93,75%	**MUB:** 80%	**MUB:** 20%	**MUC:** 100%	-	-
0.25s-0.75s	**MUA:** 85,7% **MUD:** 6.34% **A+B:** 1.58%		**MUD:** 30% **A+B:** 20% **Artefact:**50%	**MUB:** 21.7% **A+B:** 21.7% **B+D:** 39.13%	**MUC:** 83.7% **A+B:** 13.8%	**A+B:** 50% **B+D:** 30% **C+B:** 10%

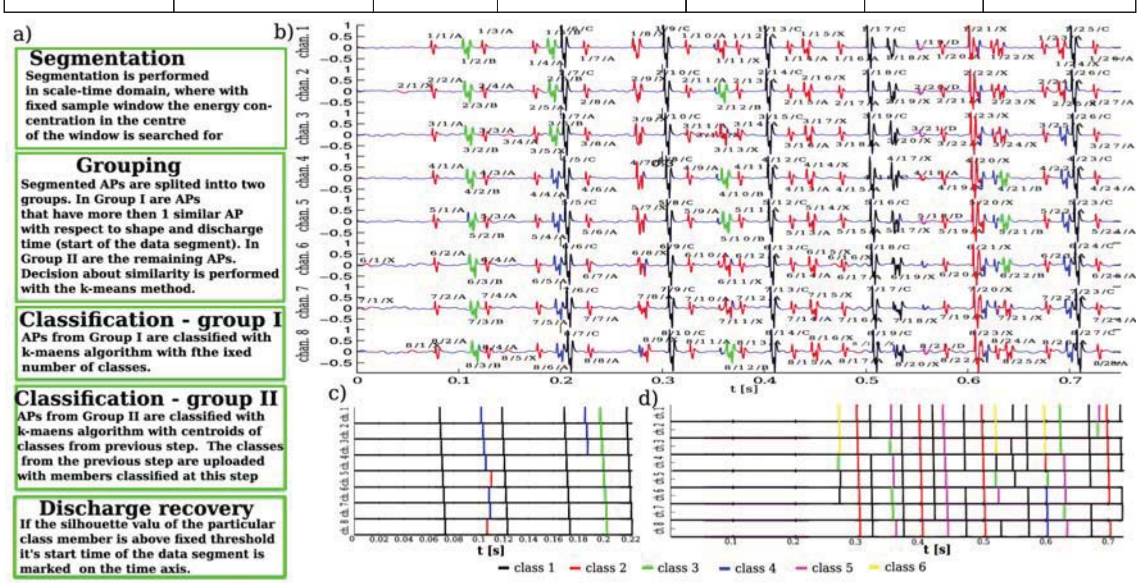

Figure 1: Algorithm sequence (a) **,** modeled (testing) signal (b) with labeled active segments (channel number/id number/MU name), and discharge patterns at particular classes (c and d).

VISUAL MANUAL CONTROL OF AN UNSTABLE LOAD: IS CONTINUOUS CONTROL NECESSARY? IS CONTINUOUS CONTROL BEST?

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AIM: The development of artificial controllers for neuro-prostheses and FES benefits from knowing the principles of normal health motor control. Contemporary understanding of motor control has developed within the engineering paradigm of continuous optimal control using internal models. We seek evidence establishing whether natural human control is better understood within an intermittent control paradigm. Sustained control of an unstable load is required for human balance and for manual control in specific circumstances. Contemporary analysis understands and defends the position that such control is continuous. Specifically, for sustained control of an unstable load we ask: is continuous control necessary? Is continuous control best?

METHODS: Using a uniaxial, contactless joystick, 11 participants performed visual manual, compensatory tracking of an unstable, second order load. The virtual load had an unstable time constant equivalent to the inverted pendulum dynamics of a standing adult. Participants were instructed to control the load using intermittent or continuous contact of the joystick. An unpredictable, multi-sine disturbance in the frequency range 0.1-10 Hz was added to the joystick signal to provide more information on the human control process.

RESULTS: Control using intermittent rather than continuous contact of the joystick resulted in significant changes, namely: - superior position control and velocity minimisation, - a reduced feedback time delay, - greater robustness to changing actuator gain, and paradoxically in higher bandwidth control gain.

CONCLUSION: Using continuous manual tracking of an unstable load, the results show that intermittent control is entirely natural and can be more effective than the more continuous counterpart. This insight is valuable for the design of artificial controllers for use in rehabilitation.

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USE OF SURFACE EMG DURING FOREST SIMULATOR OPERATIONS

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AIM: The forest industry is a major economic sector of Canada. It is also one of the most dangerous industries for workers. The use of mechanized mobile machines has reduced injuries that forest workers suffered due to manual labor, however, these machines have also created other concerns such as increased length of the work day, repetitive strain injury, and increased postural loads due to sitting in a confined space. It is critical to obtain objective data for employers to develop appropriate work practices for this industry, however ergonomic field studies of this industry are lacking mainly due to the difficulties in obtaining comprehensive data while operators are cutting trees in the woods and the cost to individual contractors due to data collection. In Canada, the use of Harvester simulators offer a safe and cost-effective method for studying harvester controls and techniques without undue stress to the workers. The purpose of this study was to obtain objective data regarding the stress operators face during typical harvesting operations to develop better work practices.
METHODS: Students currently training in a forest machine operations course were recruited for this study. Four operators (1 female and 3 males, mean age = 24.6 ± 1.3 years, mean height = 172.7 ± 4.6 cm, mean weight = 75.4 ± 27.4 kg) participated in this study. Prior to testing, the operators were provided with an overview of the testing and asked to complete an informed consent form. An eight channel telemetered (i.e. wireless) surface EMG system (Telemyo 2400R, Noraxon USA Inc., Scottsdale, AZ) was used to collect the data in this study. Silver-silver chloride, bipolar, surface electrodes (Duotrodes) were placed over the flexor carpi radialis, brachioradialis, upper trapezius and posterior deltoids of both arms. Operators were then instructed to “clear cut everything in front of you.” This resulted in 5 specific tasks: 1) positioning of the machine, 2) selection of the tree, 3) sawing and picking up the tree, 4) cutting and sorting the timber and finally 5) driving to the next tree site. The operators were then asked to “continue to clear cut everything in front of you.” This activity was sustained for 2 hours and EMG data were collected at the beginning, at the midway point (after 1 hour) and at the end of 2 hours. The mean EMG amplitude and median frequency for each event were compared at the three time intervals. Mean percentage decreases in the median frequencies were monitored to see evidence of fatigue (DeLuca, 1997). The EMG was also used to monitor the dynamic activity throughout the operation. In addition to the EMG data, the volume and stem count of the trees harvested was recorded to provide evidence of an operator’s overall production. The ACGIH®TLV® for Hand Activity scale was used to determine the hand activity level rating.
RESULTS: It was found that there were increases in the activity of the left upper trapezius, brachioradialis and the right brachioradialis, flexor carpi radialis, posterior deltoid and upper trapezius muscles after 2 hours of operation of the Simulator. The right upper trapezius showed evidence of muscle fatigue with decreases in the median frequency over time. The hand activity level rating showed an increase in effort from “barely noticeable” to “noticeable effort after 2 hours of operation.
CONCLUSION: Preliminary data suggests that while the movements used in the Simulator do not require large force, they are repetitive and constant and can result in muscle fatigue. This suggests that long term operation of mobile machines may result in fatigue and operators future studies should examine job design.