7th International Head-Out Water Immersion (HOWI) Symposium

From Bathing to Space and Daily Living

University of Tartu, May 17-18, 2008.

PROGRAMME AND ABSTRACTS
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Karl Kirsch, Inessa Kozlovskaya, Claude Gharib, Dag Linnarsson and Helmut Hinghofer-Szalkay

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PROGRAMME

SATURDAY, May 17

8.30 – 9.15 Registration (Assembly Hall of the Main Building of the University of Tartu, No 1 on the map provided for you amongst the symposium materials)

Opening ceremony
9.15 – 9.30 Opening remarks
9.30 – 10.15 Active Life Span Professor Marco Narici from Manchester Metropolitan University, UK: "Musculoskeletal adaptations to chronic inactivity"
10.15 – 11.00 Professor Tadaaki Mano, Founding Member of Association for Patient-Oriented Research, President of Gifu University, Japan: "Autonomic nerve functions and the influence of aging in head-out water immersion"
11.00–11.20 coffee break
11.20 – 12.05 Kaisa Mannerkorpi, PT, Associate Professor Sahlgrenska Academy, Gothenburg University, Sweden, Institute of Medicine/Rheumatology, and Institute of Neuroscience/Physiotherapy: "Physical exercise in temperate pool"
12.05 – 12.50 Alamelu Sundaresan, Associate Professor Texas Southern University Osteoimmunology and Integrative Physiology Laboratory, and NASA/Johnson Space Center, USA: "The effect of microgravity on the immune system"
13.00 – 13.30 Press conference
13.00 – 14.00 Lunch (University cafe, No 4 on the map)
14.30 – 16.30 City walk (meeting point at the front door of the main building)
19.00-20.00 Concert of the Female Choir of the Estonian Academy of Science in Jaani Church (situated approximately one cm to the North from No 4 on the map, where is the street name Lüübeki)
20.00….. Conference dinner in the restaurant Volga (address Küütri 1, just across the street from No 6 on the map)
SUNDAY, May 18

9.30–10.00 Registration (Biomedicum, No 43 on the map)
10.00–10.45 D. Linnarsson, SWEDEN FORTY YEARS OF PHYSIOLOGY: FUN, FRIENDS AND FAILURES
10.45–11.15 O. Hämmäinen, A. Remes, FINLAND EMG MEASUREMENTS IN SUBMERGED ZEROGRAVITY SIMULATION
11.15–11.45 coffee break and posters (Biomedicum)
11.45–12.15 E. Tomilovskaya, A. Kirenskaya, V. Novototsky-Vlasov, I. Lazarev, I. Kozlovskaya, RUSSIA EFFECTS OF 6-DAYS DRY IMMERSION ON SLOW CORTICAL POTENTIALS IN THE ANTISACCADIC TASK IN DEPENDENCE OF EYE DOMINANCE
13.00–14.00 Lunch (Building of the Institute of Technology, No 40 on the map) and posters
14.00–14.30 Ü. Pechter, M. Rosenberg ESTONIA AQUATIC REHABILITATION PROGRAM FOR CHRONIC KIDNEY PATIENTS AT THE UNIVERSITY OF TARTU
14.30 – 15.00 closing remarks

POSTERS

Ü. Pechter, K. Köälvald, Z. Riispere, M. Rosenberg, ESTONIA
EFFECT OF WATER IMMERSION TO KIDNEY INSUFFICIENCY IN RATS WITH 5/6 NEPHRECTOMY

A. Shpakov, A. Artamonov, RUSSIA
EFFECT OF 6-DAYS IMMERSION ON HUMAN LOCOMOTION KINEMATICS AND ELECTROMYOGRAPHIC PARAMETERS

R. Viir, K. Rajaleid, M. Pääsuke, ESTONIA, SWEDEN
MUSCLE VISCOELASTICITY IN PARTIAL WATER IMMERSSION MODEL

R. Viir, ESTONIA, FINLAND
NOVEL WATER IMMERSION FACILITY – ERGONOMIC TUBE

R. Viir, M. Pääsuke. ESTONIA, FINLAND
MEASURING MUSCLE VISCO-ELASTICITY IN HORIZONTAL BED REST MODEL FOR BETTER UNDERSTANDING OF SEDENTARY LIFE STYLE

ABSTRACTS
(plenary lectures first and others following in alphabetical order)
MUSCULOSKELETAL ADAPTATIONS TO CHRONIC INACTIVITY

Marco V. Narici\textsuperscript{a}, Martin Flück\textsuperscript{a}, Joern Rittweger\textsuperscript{a}, Olivier R. Seynnes\textsuperscript{a}, Pietro E. di Prampero\textsuperscript{b} and Rado Pišot\textsuperscript{c}

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Introduction
Space exploration represents one of the main achievements of mankind of the 20\textsuperscript{th} century. However, long-term survival in space is a challenge and amongst the many problems faced by the human body, muscle atrophy is a major limiting factor for maintaining physical performance and mobility in microgravity and upon return to 1-g conditions. Here we present the results of three studies simulating microgravity (bed rest and unilateral lower limb suspension) aimed at understanding the mechanisms of muscle atrophy and the functional consequences thereof.

Methods
Changes in lower limb muscle cross-sectional area, muscle fibre length pennation angle and maximum voluntary contraction, were respectively measured by MRI, ultrasound and dynamometry, before, during and after two bed rest (BR) studies (35-day Valdoltra, Slovenia, 2007 study and 90-day, ESA Toulouse LTBR 2000-1) and one 23-day unilateral lower limb suspension (ULLS) in a total of 19 human males. Vastus lateralis muscle biopsies were obtained in the 35-day BR and in the 23-day ULLS studies to identify markers of muscle atrophy and changes in protein synthesis were assessed to understand their contribution to muscle atrophy.

Results and Discussion
Muscle atrophy, regardless of the above disuse models, was found to be a very rapid phenomenon, muscle CSA decreased with a rate of 0.4-0.5%/day, falling to 5% after 10 days of ULLS and 15-17% (P<0.01) after 30-35 days of BR. The early phases of atrophy (first two weeks) were accompanied by a massive decrease (-50%) in protein synthesis. This early atrophy, mostly due to the decline in protein synthesis, is associated with a rapid remodeling of muscle architecture; within 7-10 days of BR and ULLS muscle became shorter by 6-8% (P<0.001), indicating a loss of sarcomeres in series. Concomitant with this sarcomere loss was a significant depression in content of focal adhesion kinase (FAK), a cytoskeletal protein known to be involved in mechanotransduction. From a functional point of view, the loss of muscle CSA and fascicle length were associated with a loss of muscle force and power. These studies show that muscle atrophy is a very fast phenomenon driven, in its early phases, by a decline in protein synthesis. Atrophy also involves a remodeling of muscle structure, indicating a rapid loss of sarcomere in series. Our findings suggest that removal of gravitational loading on muscle fibres affects the cellular processes of mechanotransduction resulting in changes in cytoskeletal proteins involved in the regulation of sarcomere number.

Hence rehabilitation to combat disuse-atrophy should start in the very early phases (first two weeks) of the inactivity period.
Financial support of ASI (OSMA Bed Rest project), ESA (ULLS study) and of the Ministry of Defence of the Republic of Slovenia is acknowledged

AUTONOMIC NERVE FUNCTIONS AND THE INFLUENCE OF AGING IN HEAD-OUT WATER IMMERSION

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Introduction: Human standing posture is controlled by various reflex mechanisms. Not only sensory-motor reflexes to maintain antigravity muscle functions, autonomic neurohumoral reflexes are important to maintain body fluid distribution and blood pressure in standing humans. One of important outputs of autonomic neural reflexes to maintain blood pressure is vasoconstrictive muscle sympathetic nerve activity (MSNA). We have elucidated that microneurographically-recorded MSNA plays age-dependently essential role to maintain blood pressure homeostasis against gravitational input from the head to the leg (+Gz) in the human body. We aimed to elucidate how gravity and age dependent MSNA and related autonomic neurohumoral functions are modified by microgravity simulated by thermoneutral head out water immersion (HOWI). We also aimed to clarify the effect of water temperature of HOWI on changes in body weight, urine volume, sweating and related hormonal functions.

Subjects and Methods: Subjects were healthy human subjects aged between 18 and 76 years old. We used water immersion facilities in Nagoya University, Nagoya, Japan. MSNA was recorded by means of microneurography from the tibial or peroneal nerve. We measured MSNA and related autonomic functions in subjects who kept standing in a water immersion chamber. The subjects were immersed in thermoneutral water of 34° up to the level of navel, breast, shoulder and neck. The influence of aging on MSNA responses to thermoneutral HOWI was analyzed. We also compared changes in body weight, urine volume, sweating and related hormonal functions during and after thermoneutral and hot (40°) HOWI.

Results: 1. MSNA was strongly suppressed by thermoneutral HOWI up to the neck of standing human subjects depending on the level of the immersion level. 2. There was a significant correlation between leg volume and MSNA, while a negative correlation between stroke volume/cardiac output and MSNA in the course of thermoneutral HOWI. 3. HOWI-induced suppression of MSNA decreased with advancing age. 3. Skin sympathetic nerve activity was also suppressed by thermoneutral HOWI, but much less than MSNA. 4. Heart rate decreased but much less than MSNA during thermoneutral HOWI. Low frequency and low/high frequency power spectral components in heart rate variability (HRV) decreased, while high frequency power spectral component of HRV increased during thermoneutral HOWI. 5. Plasma level of noradrenaline, adrenaline, antidiuretic hormone, aldosterone and plasma renin activity decreased, while plasma level of natriuretic peptide increased during thermoneutral HOWI. 6. Body weight decreased more, while urine volume increased less in hot HOWI than in thermoneutral HOWI. Vasoconstrictive hormones and sweating were higher during and after hot than thermoneutral HOWI.

Discussion: Gravity-dependent vasoconstrictive MSNA is suppressed age-dependently by thermoneutral HOWI simulating microgravity. Skin and cardiac sympathetic nerve activities also decrease but less than MSNA in thermoneutral HOWI. Vasoconstrictive hormones decrease, while vasodilator peptide increases during HOWI. Body weight decreases more during hot HOWI than in thermoneutral HOWI, depending mainly on sweating. Urine volume increases more in thermoneutral than in hot HOWI depending on difference of neurohumoral responses.

Conclusion: Vasoconstrictive MSNA is suppressed age-dependently by thermoneutral HOWI. Vasoconstrictive hormonal functions decrease during and after thermoneutral but not hot HOWI.
PHYSICAL EXERCISE IN TEMPERATE POOL

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Physical exercise is a common treatment for patients with inflammatory and non-inflammatory rheumatoid diseases and patients, aiming to improve range of motion, muscle strength, muscle endurance, aerobic capacity, overall level of activity, and so on.

Exercise in temperate pool is a feasible therapeutic modality for patients suffering from pain in joints and muscles. The temperature of pool water is commonly 30-34 degrees Celsius, which is supposed to alleviate pain and stiffness. The viscosity of water provides the resistance required in aerobic and strengthening exercises, while buoyancy facilitates the performance of movements. My talk will focus on exercise for patients with rheumatoid diseases, specifically for patients with rheumatoid arthritis (RA) and fibromyalgia (FM).
THE EFFECT OF MICROGRAVITY ON THE IMMUNE SYSTEM

Alamelu Sundaresan

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Many biological stresses are induced by spaceflight and are visible in many areas of human physiology. The most dramatic response to spaceflight is the significant loss of bone and muscle mass and function, most likely caused by skeletal unloading and reduced activity. In addition, cephalad fluid shifting, neurovestibular disturbances, and a general malaise termed “space sickness” are experienced by astronauts soon after arrival in microgravity. In many instances, the basis of the negative influence of microgravity on human systems may be investigated using cell-based systems. This communication will offer a selected review and present work of past work and invoke models to test in forthcoming opportunities on the International Space Station.

A major challenge in studying the adaptation of terrestrial life to space conditions resides in convincingly delineating the responses induced by microgravity from the radiation and stress experienced in spaceflight. Various parameters of immune function are suppressed in humans during and returning from space missions. Exposure to cosmic radiation, along with physical and psychological stresses occurs concurrently with the microgravity of spaceflight. Understanding the effect of each of these factors in the physiological changes observed during spaceflight is a formidable challenge for space research programs (e.g. for immune function which is affected independently by all three factors: microgravity, stress, and radiation).

Physiological changes in humans during spaceflight upon return to Earth have been attributed to systemic adaptation, response to stress, and lack of normal exercise. Studies from the Skylab, SL-3, and D-1 missions have demonstrated that significant physiological alterations are seen in single cell prokaryotes and eukaryotes, as well as in animal tissues. Basic cellular functions, such as electrolyte concentration, cell growth rate, glucose utilization, bone formation, response to growth stimulation, and exocytosis are modified in microgravity. Many of the physiological changes seen in humans, vertebrate and simple organisms in spaceflight may originate from dysfunction of basic biological mechanisms caused by microgravity. Aging humans share many of the symptoms seen in astronauts during spaceflight. These include reduced cardiac function, loss of bone and reduced immune response and orthostatic hypotension. It is possible that some of the physiological adaptations seen in aging may share common physiological basis with those changes seen in spaceflight. Since microgravity affects prokaryotic and eukaryotic cell function at a sub-cellular and molecular level, space offers us an opportunity to learn more about basic biological mechanisms which are essential to life.

The health status of an astronaut prior to and following space flight has been a prime concern of NASA throughout the Apollo series of lunar landings, Skylab, Apollo-Soyuz Test Projects (ASTP), and the new Spacelab-Shuttle missions. Both humoral and cellular immunity has been studied using classical clinical procedures. Serum proteins show fluctuations that can be explained with adaptation to flight. Conversely, cellular immune responses of lymphocytes appear to be depressed in both in vivo as well as in vitro. If this in vivo and in vitro depression is a result of the same cause, then man’s adaptation to outer space living will present interesting challenges in the future. Since the cause may be due to reduced gravity, perhaps the designs of the experiments for space flight will offer insights at the cellular levels that will facilitate development of mechanisms for adaptation. Furthermore, if the aging process is viewed as an adaptational concept or model and not as a disease process, then perhaps space flight could very easily interact to supply some information on our biological time clocks. The connotations to inflammatory diseases such as rheumatoid arthritis, and osteoporosis also need to be gleaned.

Microgravity as an experimental perturbation also offers a new blueprint in cellular adaptation.
EMG MEASUREMENTS IN SUBMERGED ZEROGRAVITY SIMULATION

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A solution for underwater EMG recordings has been developed. The system consists of ME6000 Biomonitor System (4-16 channels) using different sensors (EMG, ECG, EEG and inclinometers, goniometers, accelerometers etc). It monitors data on-line via Wireless lan (WLAN) or USB link. With electrodes applied directly to the skin, it simultaneously measures electrical activity from four up to sixteen muscles. As impulses can be small (even 1µV), accurate amplification is required. Each amplifier is connected directly to the grounding electrode. This eliminates disturbances. Amplifiers are sealed to prevent water to destroy circuit board. The device acquires data with 14 bit analog to digital converter and stores them into 1-2 Gigabyte flash RAM memory integrated on board. Parameter setting can be programmed either by using PC control or from the menu of stand alone device. Sampling frequencies can vary between 1000, 2000, 5000 or 10.000 samples/sec. Measured data can be transferred online for analysis with the aid of specially designed software. MegaWin PC software expands system features for creating specific protocols for muscular assessment, performing various calculations, obtaining results and producing reports. In under water measurements special waterproof kit is used. The waterproof bag consists of following components: Preamp cables (fixed the bag) Transparent plastic rear plate (to fix the belt and support the waterproof module).

![Fig 1. Waterproof case.](image1)

![Fig 2. Waterproof case opened and closed.](image2)

Typical recommended recoding time is 15-20 minutes per session. The signal measurement area is protected with laboratory/skin tape to avoid disconnection and short circuiting. Due the small currency in
amplifier inputs there are no significant leakage currents between +/- inputs even under the water. There are a few systems in use.
EFFECT OF WATER IMMERSION TO KIDNEY INSUFFICIENCY IN RATS WITH 5/6 NEPHRECTOMY

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Background: The possible benefits of aquatic environment to the kidney function in renal failure stages are not much been investigated. Some experimental studies have shown that water environment could influence renal function positively: plasma renin activity is reduced contributing to renal vascular pressure and sodium excretion. Water immersion causes increase in renal blood flow and contributes to the lowering in renal sympathetic nerve activity, renal vascular pressure and decrease in plasma renin activity. Non-swimming aquatic exercises have shown a beneficial effect, particularly lowering blood pressure in hypertensive patients. We hypothesized that the aquatic environment could improve renal functioning and even slow the progression rate.

The aim of our study was to investigate the effects of swimming and water immersion to the rate of progression of experimental CRF after 5/6 nephrectomy (5/6NPX).

Methods: Wistar rats were divided into matched groups and studied during 18 weeks. One group was subjected to thermoneutral water immersion and swimming without exhaustion 30 min daily for 12 weeks. Control groups remained sedentary. Chronic studies of systolic blood pressure and urinary protein excretion rate (mg/24h) were performed. Renal morphology was studied at the end of the study.

Results: The main systolic blood pressure was significantly higher in control 5/6NPX animals compared to the swimming-immersion group. Proteinuria was reduced significantly in water immersion group compared to animals without therapy and the degree of glomerulosclerosis and interstitial fibrosis was in water therapy group significantly less prominent.

Conclusion: These results point on the additional renoprotective properties of long-term water immersion and daily aquatic therapy in rats with CFR. Protective therapy may have the greatest impact if initiated early in the course of renal failure development.
AQUATIC REHABILITATION PROGRAM FOR CHRONIC KIDNEY
PATIENTS AT THE UNIVERSITY OF TARTU

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Introduction
Most chronic nephropathies lack a specific treatment and progress relentlessly to end-stage renal
disease. Protective therapies may have beneficial impact if initiated early in the course of renal
failure development (1). In addition of pharmacological treatment, a complex of combined
nephroprotective and cardioprotective treatment strategies could be included to the care of patients
with chronic renal failure (CRF), especially encouraging patients of participation in an exercise
conditioning. Beside of wide variety of aerobic exercise possibilities, aquatic exercise is a novel
approach in CRF patients exercise therapy. Water-based aerobic exercise program could allow
older and obese patients to gain all the advantages of land-based exercise more easily. Water
immersion causes increase in renal blood flow and contributes the lowering in renal sympathetic
nerve activity, so ameliorating the aggravating effects of exercise on renal function.

Material and methods
Aquatic exercise therapy for patients with mild to moderate progressive CRF was introduced in the
year 2003 at the Department of Sports Medicine and Rehabilitation in Tartu University Hospital.
We suggested regular, long-time (at least 12 weeks duration) provided exercising, 2 times a week.
The intensity of exercise is provided low, with a prolonged warm-up and cool-down period.
Groups of patients exercised in the pool with total immersion to the shoulder supervised by a
trained physiotherapist.

Results and discussion
The results showed that aquatic exercise could be a supportive method in complex of
renoprotective strategies. It caused significant improvement of renal functional parameters, had
beneficial effects on physical capacity and ameliorated significantly the oxidative stress status of
CRF patients (2).
We invite now constantly patients to come twice a year to participate in a 12-week regular aquatic
exercise program. The ongoing study will include 5 years follow-up and conclusions will be made
at the end of 2008.

References
   Preventing end-stage renal disease: the potential impact of screening and intervention in
EFFECT OF 6-DAYS IMMERSION ON HUMAN LOCOMOTION KINEMATICS AND ELECTROMYOGRAPHIC PARAMETERS

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Goal of the work was determination of the role of support removal in the development of locomotion disorders that were recorded usually in consequence of exposure in microgravity.

Methods. The investigation involved six volunteers who had signed the Informed Consent to participate in the experiment. The microgravity effects were simulated using the “dry immersion” model (E.B.Shulzhenko, I.F.Vil'-Viliams, 1973) with human subjects separated immersed in the water being from water by a thin elastic waterproof film. Duration of immersion was 7 days long. Before the exposure and on day 6 of immersion the subjects fulfilled a locomotion test, i.e. walked along the solid surface at the pace of 90 steps/min set by metronome. In each test session, the subjects made five attempts consisting of 5 steps. As subject walked, locomotion kinematics was video recorded and coordination evaluated based on electromyography. Analysis included calculation of the dependence of the knee joint velocity on its angle, and of the kinetic energy of joint angular motions.

Results. Six days in immersion did not alter the amplitude of knee joint angular motions. However, energy expenditure and angular velocity decreased markedly. On the average, angular velocity of the knee joint during flexion and extension was decreased by 6% and 6.5%, respectively. The calculated energy expenditures on flexion and extension dropped by 14% and 18%, respectively (p<0.05).

Conclusion. The observed changes correlate with the decline of strength properties of leg muscles (Netreba et al., 2003) due to the reflectory decrease of muscle stiffness during immersion (Grigoriev et al., 2004; Kozlovskaya I.B. et al., 1987).
BODY TEMPERATURES DURING THREE LONG-DISTANCE POLAR SWIMS IN WATER OF 0-4°C

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We report body temperature responses in a single individual to 3 swims of 1000 m or longer in ice-cold water (0-4°C) during which he swam the normal crawl stroke with his face in the water whilst wearing only a swimming costume. The swims were carried out in both Polar Regions. The temperature measurements allowed us to define the limiting time for which he was able to swim and the distance he was able to cover, and to speculate on the physiological adaptations that allowed him successfully to complete these swims.

He began each swim with a rectal temperature between 37.8-38.4°C which he maintained above 37.5°C for more than 20 minutes. His lower limb muscle temperature fell to below 32°C, and remained at that level for over 1 hour whilst rectal temperature had returned to a normal level.

In a separate laboratory test, his shivering threshold was 36.6°C, and it seemed that he exited the cold water close to the threshold, after rectal temperature had decreased approximately 2°C.

There was a marked post-swim after-drop in his rectal temperature reaching 33.6°C 13 minutes after a 1.6 km swim in water of 2-3°C.

The swimmer’s unusual ability appears to be due to many factors. The subject began all events, including the preparatory training swims, with a heightened rectal temperature. This anticipatory thermogenesis before exercise can be considered beneficial since it allowed him to maintain his core temperature at a higher level for a longer time than might otherwise been the case.

He was also able to maintain his elevated core temperature for between 10-15 min while swimming in cold water, and he usually stopped swimming near his shivering threshold. Shivering increases rate of body cooling, and disturbs swimming performance. He might also produce more heat than expected for the swims. This may be due to inefficient swimming technique or continued high rate of thermogenesis during swimming. Before the swims, he also purposefully gains weight from the normal (ca 86 kg) up to 100 kg, and this gives added protections against the cold. The persistently low muscle temperature during core warming indicates an enhanced counter-current heat exchange mechanism, that has been previously observed in Korean cold water divers.

This study may identify the limiting durations for swimming at 0-4°C without protective clothing. The subject neared his limit when he swam 1650 m in 30 minutes in water at 2-3°C. In water at 0°C, the limits are likely less but still greater than 1000 m or 20 minutes.
EFFECTS OF 6-DAYS DRY IMMERSION ON SLOW CORTICAL POTENTIALS IN THE ANTISACCADIC TASK IN DEPENDENCE OF EYE DOMINANCE

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The study was carried out in 12 healthy volunteers with the right (group 1, 7 subjects) and left (group 2, 5 subjects) eye dominance before and during simulated weightlessness (dry immersion - DI). Three LEDs, one in the center and two others 10° to the right and to the left from it (peripheral target stimuli – PT) were used for visual stimulation. Subjects performed the antisaccade task, i.e. made saccades to the horizontal mirror position of the PT in the opposite visual half-field. EEG was recorded from 19 sites. Slow cortical potentials ($\tau$=5 s) were averaged time-locked to the PT onset. Mean amplitude of the potentials was estimated in the interval 600 ms before PT.

Topography mapping of PSN revealed two phases reflecting cortical preparatory processes in group 1 before DI. Early negative wave (600-400 ms before PT onset) was represented by CNV-like potential that localized symmetrically in frontal-central-parietal area with a maximum at the middle frontal area. Late negative wave (last 200 ms before PT onset) consisted of two foci of negativity over frontal and parietal areas with left and midline preponderance. The subjects of group 2 demonstrated generally reduced amplitude of negativity especially in frontal region when compared to subjects of group 1. The PSN topography in group 2 was asymmetrical and covered midline and left central parietal areas during both early and late period of presaccadic preparation.

After exposure to dry immersion there was observed reduce of PSN amplitudes in both groups. The basic difference in topography consisted in inversed lateralization of the negative wave: in contrast to the control conditions, the immersed subjects displayed the area of negativity over occipital and parietal areas (group 1) and central-parietal-occipital areas (group 2) of right hemisphere. Exposure to dry immersion was also followed by worsening of the saccade characteristics (error percent and latencies) in subjects with the left eye dominance, and didn’t affect the task performance in group 1.

Obtained results correspond to significantly increased error and accident rate in drivers and pilots with the left leading eye compared to subjects with right one (Dobrokhotova, Bragina, 1987, 1994; Zvonikov, 2001). Significant reduce of PSN amplitude in frontal region that was revealed in subjects with the left eye dominance correlates with Geschwind-Galaburda (1987) model of cerebral lateralization according to which displacement of the dominance to the right hemisphere may be a result of neurodevelopmental disorders.
The study was supported by grant RFBR N 06-04-49660-a and BIAL 58/04.
MUSCLE VISCOELASTICITY IN PARTIAL WATER IMMERSION MODEL

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In the context of Water Immersion (WI), gravitational physiology and water sports, rehab and prevention meet each other in the most natural way. One of the most important targets of these studies is the same – life systems responses to changes in Function of Support (SF). Famous Borelli stated: muscular tensions inevitably have to be involved in holding posture. Kurutz (1) has shown that in WI antigravity SF diminishes and height increases up to 3cm from i/v discs upraising. Herzog with colleagues (2) came to conclusion that contraction cross-bridge kinetics is assisted by Ca-dependent increase in titin stiffness.

AIMS Tibialis Anterior muscle (TA) as a representative of the musculoskeletal support system was used to determine the effect of partial water immersion (PWI) microgravity simulation on muscular tone and viscoelastic properties; and whether this PWI effect could be subjectively perceivable by participants themselves.

METHODS 15 healthy female people participated. Questionnaire was used to clarify whether loading difference is subjectively perceivable. Myometric measurements (3) of the TA muscle on both sides of the body were recorded while the participants were in relaxed supine position in a special WI ergo-tube device without water and while the tube was fulfilled with thermo-neutral water up to occiput and tube bottom contact (PWI) level.

RESULTS

Figure 1. Box plot representing A the stiffness of the TA muscle (N/m, Y-axis), B the tone of the TA muscle, characterized by oscillation frequency (Hz, Y-axis) and C the elasticity reciprocally characterized by (unit less parameter, Y-axis) the logarithmic decrement of damping of the TA muscle in standardised supine position in ergo-tub with and without PWI to compare average levels.
TA muscle stiffness and tone decreased significantly (p<0.05), no difference was in elasticity.

CONCLUSION Decrease of TA muscle tone and stiffness in PWI show that this so called non-postural muscle is also involved in antigravity SF. It seems that immediate variation sensing of gravitational force, specific for our PHOWI model, might be related to prompt changes in muscular tone and visco-elasticity. Better understanding of muscle visco-elastic response to WI gives possibility to refine different water-sport and leisure activities and preventive and recovering interventions. Also, it will probably enhance patients' motivation for water exercising.


NOVEL WATER IMMERSION FACILITY – ERGONOMIC TUBE

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BACKGROUND In head-out water immersion (HOWI) and Russian group’s so called dry immersion (DI) models the hydrostatic pressure on different sites of the body surface are equal so that the experimental conditions are more close to the complete inherent supportlessness than in Bed Rest model. Immersed human body, like every body, except its head if resting out of water, is subject to Archimedes’ Law. This occurrence can be felt when enough water is drained from a full bathtub to allow the gravitational force again to press the body to the bottom of the tub. Such immediate variation in sensing the gravitational force as in HOWI model (2) is not detectable in BR studies. Also DI studies do not report this phenomenon.

HOW ERGO-TUB WORKS Muscle measurement requires standardisation; for passive tension measurements the condition involving absence of any muscle activity is considered the best one. While lying in the ergo tub, the bottom curvature of the tub provides continuous posterior contact, hips and knees are slightly flexed and test person is supported by the bottom surface of the tub avoiding the floatation. All the muscles are about the same distance away from the water surface avoiding the excess pressure on the legs present in the regular sitting position WI tank. The gravitational force gradient is more uniform in this position where state of BR inactivity is coupled with presumable reduction of transverse G-Stress influence similarly as in DI model.

The head is placed higher than the rest of the body, so that when filling the tub to a certain level the body will start loose weight earlier than the head. The tub is filled partially, so the water reaches up to the point of contact between occiput and the tub’s surface. In this condition the test subjects feel slightly relieved from the gravity while still being in posterior contact with the bottom of the tub and free floating is avoided for neck muscles to become active in trying to hold the position of the body. Muscles on the front side are most easily measurable in this position with the myometric device in both steady (relaxed and voluntary contraction) states.

BENEFITS, FURTHER STUDIES Comparing muscles with and without WI is possible and necessary to explain the state of the tensed network of overall muscular system in microgravity vs.
ground based condition. WI study can be refined to deliver more information by including parallel measurement of EMG, ECG, myometrical, blood flow, and microneurography recordings. The protocol of a more complex study can involve the gradual WI and after a while a gradual removal of WI, this can be considered as a model of the very short flight into weightlessness and return.

Increasingly popular rehabilitation exercised in water needs basic understanding of muscle system visco-elastic and other characteristics and we hope the ergo-tub will be proper facility also for health benefits in this purpose.

MEASURING MUSCLE VISCO-ELASTICITY IN HORIZONTAL BED REST MODEL FOR BETTER UNDERSTANDING OF SEDENTARY LIFE STYLE

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BACKGROUND The human body has to support itself against gravity throughout life, even whilst lying down, in this position the longitudinal loading is eliminated. Support function is a priori a subject of Space Life studies. Horizontal bed rest (BR) micro-gravity model is basically build on the idea of different positioning relative to Earth radius. The applications of BR research reveal the crucial role of gravity to health (1). A human being rests in horizontal position every night and about one third of his lifespan; this is trivial and works as the most natural recovering intervention to start the next day. It is not rare that the remaining 16 h people predominantly stay in sitting position. Two terms ‘sedentary life style’ and ‘sitting immobility’ are essentially near synonyms. Latin word ‘sedentarius’ means ‘one that sits’. As early as 1700 Bernardino Ramazzini observed that the chief cause of health problems in clerks was their constant sitting, but significance of this observation was lost in the intervening three centuries. Also, objective registration of ‘...muscular tensions...inevitably have to be involved in holding posture’, as stated by Borelli in 1685, has been unavailable. The goal of study is to gather quantitative information about the trapezius muscle tone and the visco-elastic properties in upright and horizontal positions.

METHOD We register Upper Trapezius muscle (UT) stiffness, tone (frequency of damping oscillation) and elasticity (reciprocal of logarithmic decrement of damping) in 22 women in standing, sitting and supine positions with myometric technology (2,3,4,5,6).

RESULTS

Figure 1. Tukey-Kramer plots: a) Stiffness (stiff) [N/m] and b) tone (freq) [Hz] in standing 236.07 N/m and 14.76 Hz, sitting 225.7 N/m and 14.26 Hz, lying 125.8 N/m and 9.57 Hz respectively. Stiffness and tone in standing and lying p < .0001, stiffness in lying p = 0.04 and tone in lying p = 0.03. Positioning doesn’t influence the values of UT elasticity (left side 1.09, right 1.05, p=0.09).
DISCUSSION It seems obvious that there is a difference in tension in muscle under the force of gravity when in the standing/sitting position and when lying down. Yet, oddly enough there has been no prior direct measurement of this difference. Myometry gives a measurable difference. The immediate decrease in UT muscle tone and stiffness clearly demonstrates that the upright position requires greater tension and stiffness to maintain. A proper appreciation of this simple phenomenon might lead to new ways of treating and preventing work-related neck and shoulder disorders in sedentary workers. It is suggested, that the mechanical load from the gravity force may be a strong factor behind several pathological states and the process of ageing (7). Musculo-skeletal disorders in the neck and shoulder area are coming to be a major occupational concern globally. It seems plausible to suppose that many of the gentle movements performed in the supine position few minutes regularly may result in different effects with respect to the micro and macro circulation as compared with those done in the semi or upright positions.