Nutritional supplement use among school level Athletes in Sri Lanka

E.M. Dassanayaka¹ and N. Silva²

¹Bio Medical Sciences, International Institute of Health Sciences Welisara, Kadawatha, Sri Lanka and ²National Hospital of Sri Lanka, Colombo, Sri Lanka

Introduction: Sports supplements use is seen among school athletes in Colombo but their actual practices and recommendations and associated risks are unknown. As well as the knowledge on the products they use is unknown.

Objective: To assess the knowledge & Practices regarding approved and non-approved sports supplements and the knowledge on banned doping agents.

Methods: A descriptive study was done on 130 conveniently selected school athletes among leading schools in Colombo using a self-administered questionnaire.

Results: The sample population included 13.1% female athletes and 73.4% Male athletes. The participants were from ages 15-20. From the majority 62.3% took dietary supplements and 56.9% of the population took supplements without a doctor’s recommendation. Only 13.1% would go to a physician to find information on supplements. 68.4% of the sample took information on supplements from unreliable sources. 48.5% believes that supplements are right for them out of which 58.7% relied on the supplement label to select the right supplement. 50% believes that energy drinks can improve sports performance. 56.9% agrees that with doping body shape and muscle mass can be increased. 55.4% agrees that doping can cause harm to the user. Also 45% disagrees respecting individuals who drug dope. 2.3% from the sample have taken a banned substance.

Conclusions: The use of nutritional and sports supplements are common among school level athletes, the use of supplement and other doping substances without consultation may be dangerous for Athletes.

Key words: Sports supplements, Drug doping, Performance

Dr. Nishan Silva, Dr. Kithsiri Edirisinghe

Where applicable, the authors confirm that the experiments described here conform with the Physiological Society ethical requirements.
The impact of swimming on the prothrombotic state and fibrinolytic activity in a rat model of nonalcoholic fatty liver disease

I. Bin-Jaliah1, M.A. Dallak1 and H.F. Sakr1,2

1Department of Physiology, College of Medicine, King Khalid University, Abha, Saudi Arabia and 2Department of Medical Physiology, Faculty of Medicine, Mansoura University, Mansoura, Egypt

The consequential positive energy balance of modern lifestyles, frequently characterized by physical inactivity and unhealthy diet intake, is a major cause for insulin resistance and the metabolic syndrome. The liver, as a key metabolic tissue, develops obesity-related complications. Nonalcoholic fatty liver disease (NAFLD) is associated with increased incidence of cerebrovascular and cardiovascular accidents. The aim of the present work was to investigate the effects of swimming exercise on the prothrombotic factors and fibrinolytic activity of the blood in a rat model of NAFLD.

Forty rats were randomly divided into four groups (n=10 for each). Group 1 rats, fed with standard laboratory chow for 15 weeks, were used as control (Con). Group 2 rats (Con+Ex) were fed a standard laboratory chow for 15 weeks and obliged to swimming exercise from the 11th week to the 15th week. Group 2 rats fed a high-cholesterol diet with 10% fructose solution (HCFD) for 15 weeks. Rats in group 4 (HCFD+Ex), fed with high-cholesterol diet with 10% fructose solution (HCFD) for 15 weeks and obliged to swimming exercise from the 11th week to the 15th week. After 15 weeks, serum glucose, insulin, lipogram, plasminogen activator inhibitor-1 (PAI-1), fibrinogen, von Willibrand factor (vW factor), Fibrin degradation products (FDPs), endothelin-1 (ET-1), intercellular adhesion molecule (ICAM), and vascular cell adhesion molecule (VCAM) were assayed. Platelet count, bleeding time, clotting time, prothrombin time (PT), activated partial thromboplastin time (aPTT) and adenosine diphosphate (ADP) platelet aggregation were measured. Data are expressed as mean±S.D. and significance (P<0.05) tested with ANOVA.

HCFD fed rats showed a significant increase in systolic blood pressure from 122±5 to 144±8 mmHg, with increased body weight by 21% compared to control rats. They had significantly higher plasma glucose, insulin, lipid profile and HOMA-IR. PAI-1 increased significantly from 36.33±3.52 to 57.04±5.75 ng.ml⁻¹ and fibrinogen from 188.34±12.51 to 350.38±26.92 mg.dl⁻¹. HCFD rats had also higher FDPs, vW factor, ET-1, ICAM, VCAM, and platelet aggregation, with shorter bleeding time by 25%, clotting time by 27%, PT by 29% and aPTT by 35% versus control rats. In contrast, swimming exercise significantly decreased the gained body weight by 15%, glucose by 30%, insulin by 35%, and lipid profile compared to HCFD group. In response to exercise PAI-1 decreased to 42.14±4.26 ng.ml⁻¹. Fibrinogen, FDPs, vW factor, ET-1, ICAM, VCAM, platelet aggregation decreased to normal values with normalization of bleeding time, clotting time, PT and aPTT.
It could, therefore, be concluded that NAFLD increases the prothrombotic markers and platelets adhesion and aggregation. Swimming ameliorates the hypercoagulable hypofibrinolytic state induced by HCFD in a rat model of NAFLD.

*Where applicable, the authors confirm that the experiments described here conform with the Physiological Society ethical requirements.*

---

**PC03**

**Effects of creatine supplementation on the airways of youth, elite football players**

P. Kippelen¹, A. Simpson¹, S. Horne¹, P. Sharp² and R. Sharps²

¹College of Health & Life Sciences, Brunel University London, Uxbridge, UK and ²Watford Football Club, Watford, UK

Owing to its well-established ergogenic potential, creatine is a highly popular food supplement in sports. As an oral supplement, creatine is currently considered safe and ethical. However, no data exist on the safety of creatine on lung function in humans. This is particularly striking considering that, in animals, creatine has been shown to exacerbate allergic lung inflammation, airway remodelling and bronchial hyper-responsiveness (1). The aim of this project was to evaluate the effects of a standard course of creatine supplementation on the airways of youth, elite athletes. Twenty Football Academy players, aged 16-21 yr, completed a randomised, double-blind, placebo-controlled, parallel-group trial. The creatine group (n=9) ingested 0.3 g/kg/d of creatine monohydrate (CM) for 1wk and 5 g/d for the remaining 7wk, whereas the placebo group (n=11) received the same dosage of maltodextrin. Airway inflammation (assessed by exhaled nitric oxide, FeNO) and bronchial responsiveness (to dry air hyperpnoea) were assessed pre- and post-supplementation. Atopic status was checked at study entry by skin prick testing. There was a trend (P=0.086, Wilcoxon test) for FeNO to increase post-CM supplementation (Table1), especially in those players sensitized to aero-allergens (FeNO increased by >10 ppb in 4 out of 7 atopic players under CM versus 0 out of 8 atopic players under placebo). Furthermore, the airways of the players supplemented with CM were slightly, but significantly (P=0.038, Mann-Whitney test) more responsive to dry air after 8wk of supplementation compared to the placebo group (Table1). Based on these findings, we cannot exclude that creatine supplementation increases inflammation of the airways in susceptible (atopic) youth athletes, and thereby, contributes to the high prevalence of asthma in elite sport (2).
Table 1. Airway inflammation and bronchial responsiveness in youth, elite football players supplemented with creatine monohydrate (CM) or placebo for 8 weeks

<table>
<thead>
<tr>
<th></th>
<th>FeNO (ppb)</th>
<th>Max fall in FEV1 post-EVH (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre</td>
<td>Post</td>
</tr>
<tr>
<td>CM (n=11)</td>
<td>22 (19-81)</td>
<td>34 (16-95) *</td>
</tr>
<tr>
<td>Placebo (n=9)</td>
<td>21 (17-34)</td>
<td>20 (16-24)</td>
</tr>
</tbody>
</table>

Values are median (interquartile range; Q1–Q3); FeNO, fractional nitric oxide in exhaled air; Max fall in FEV1 post-EVH; maximal fall in forced expiratory volume in 1 sec following 6 min of eucapnic voluntary hyperpnoea (EVH) of dry air; \* P=0.086 compared to pre-CM supplementation (Wilcoxon test); \* P=0.038 compared to post-supplementation in the placebo group (Mann-Whitney test)


This research was supported by a grant from the Union of European Football Associations (UEFA).

*Where applicable, the authors confirm that the experiments described here conform with the Physiological Society ethical requirements.*

---

**Embryonic polarity axes may be responsible for the normalization of tissue function by the interaction between human bilateral parts**

M.C. Ou2,1, D. Ou3 and C.C. Pang4

1*Obstetrics & Gynecology, Taipei Medical College, Taipei City, Taiwan, 2Obstetrics & Gynecology, Taipei City Hospital, Taipei City, Taiwan, 3Master of Science in Financial Economics, Oxford University, Oxford, UK and 4Su Women Hospital, Taipei City, Taiwan*

Objective: Ou MC decrescendo phenomenon (OuDP) is produced by placing the contralateral hand over a diseased location to produce a zone under the hand with decreased pain or inflammation [1]. Our objective is to understand the possible mechanism of OuDP.

Methods: OuDP can be induced by the patients themselves or the therapist [1] by placing the contralateral hand directly on the affected area. During 2012-2015, 147 patients with various diseases were treated with OuDP. In these patients, 56 patients was treated with both ipsilateral and contralateral hand to induce OuDP [2-5]. Though complementary therapy is exempt from informed consent by the law in Taiwan (Department Health, ROC, 1993, No.82075656), all patients agreed and provided consent for participation in this study.

Results: The 56 patients treated with contralateral and ipsilateral hand showed that application with contralateral hand resulted in OuDP for all the patients, while the ipsilateral hand resulted in OuDP for only one patient (1/56, 2.0%)—Difference between contralateral and ipsilateral hand to induce OuDP, P < 0.001, Paired t test. The OuDP showed effect of remission or cure for the diseases or relief of clinical symptoms in 144 of the 147 patients (98.0%). (Table 1)
Conclusions: The Ou HR appears to be consistently effective for treating a wide variety of diseases, such as infections, inflammation, degenerative diseases, organ dysfunction, and malignant oncologic changes. Embryological development of animals usually patterns along the embryonic axes with regard to the functional features developed during early embryonic life. Recent studies have shown the signaling system of embryonic axes imparts polarization of individual cells leading to normal function. Most human cells and tissue in adults are polarized to have normal functions. OuDP can be effectively induced with the contralateral hand, but not the ipsilateral hand, which implies that the axes of embryonic polarity, especially the left-right axis, are the potential mechanism underlying the OuDP (Figure 1). Linguistic studies have demonstrated that a space–time congruency effect exists from the left to right that is coordinated with the left-right axis of the human body. This indicates there are mutual interactions of the left to right axis between individuals that may result in a physiological response.

Table 1 The efficacy of ipsilateral and contralateral hand to induce Ou MC decrescendo phenomenon (OuDP)

<table>
<thead>
<tr>
<th>Study</th>
<th>Authors (years)</th>
<th>Patients with OuDP successfully induced</th>
<th>Patients number</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Ipsilateral hand</td>
<td>Contralateral hand</td>
</tr>
<tr>
<td>Reference 1</td>
<td>Ou et al. (2006-9)</td>
<td>0/3</td>
<td>42/42</td>
</tr>
<tr>
<td>Reference 3</td>
<td>Ou et al. (2010-11)</td>
<td>0/3</td>
<td>36/39</td>
</tr>
<tr>
<td>Reference 3, 4</td>
<td>Ou et al. (2011-14)</td>
<td>0/3</td>
<td>40/40</td>
</tr>
<tr>
<td>Reference 5</td>
<td>Ou et al. (2015)</td>
<td>1/1</td>
<td>20/20</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>1/66</td>
<td>144/147</td>
</tr>
</tbody>
</table>
Interaction of human bilateral parts

Embryo polarity axes:
1. Left-right axis (main)
2. Anteroposterior axis
3. Dorsoventral axis

Cellular polarity

Normalization of tissue function

Ou MC decrescendo phenomenon


The authors thank the encouraging and spiritual support from Ms. Ou Yi-Jen.

Where applicable, the authors confirm that the experiments described here conform with the Physiological Society ethical requirements.

PC05

Are there differences in training protocols and racehorse responses of higher- versus lower-ranked trainers?

K. Mukai¹, H. Ohmura¹, A. Matsui¹, Y. Takahashi¹, H. Miyata² and T. Takahashi¹

¹Equine Research Institute, Japan Racing Association, Shimotsuke, Japan and ²Yamaguchi University, Yamaguchi, Japan

There is great interest from both racehorse trainers and scientists in constructing effective training protocols, however, differences in protocols and the responses of horses to them remain poorly described. The purpose of this study was to investigate training programmes of racehorses in Japan to test the hypothesis that higher-ranked trainers exercise horses differently than lower-ranked trainers.

Methods - (1) GPS data loggers on 808 Thoroughbred racehorses from 42 trainers recorded training profiles of each racehorse for approximately one month. (2) Seven well-trained Thoroughbred horses (6 castrated males and 1 female; 488 ± 8 kg) ran on a 6% inclined treadmill to simulate the typical training protocol of higher-ranked (H group, top 20 of 208 trainers; 60% of maximal rate of O₂ consumption (VO₂max), 90 s; 85% VO₂max, 90 s; 110% VO₂max, 60 s) or lower-ranked trainers (L group, bottom 100 of 208 trainers; 60% VO₂max, 90 s; 85% VO₂max, 180 s; 110% VO₂max, 30 s), and arterial blood samples were drawn during the final 10 s of the run. Muscle biopsies were taken from M. gluteus medius under local anaesthesia (2% lidocaine, 2 ml/head, s.c.) before, 4 h, and 24 h after the treadmill run, and relative quantitative analysis of mRNA was performed using real-time PCR (3 replicates). Values are means ± SEM. mRNA data were analysed by two-way ANOVA with Tukey’s test and the others by paired t-test. Statistical significance was set at P<0.05.
Results - (1) Training programmes of H were of shorter distance (1137 ± 30 m) than L (1702 ± 29 m) at moderate-intensity (>6.9 and <13.3 m/s) and longer distance (307 ± 12 m) than L (211 ± 12 m) at high-intensity (>13.3 m/s). (2) Despite shorter total run distance in H (H 2279 ± 21; L 2780 ± 26 m), peak plasma lactate concentration (H 22.8 ± 2.0; L 16.1 ± 2.1 mmol/l), VO₂ (H 169 ± 4; L 151 ± 4 ml/ (kg×min)) and respiratory exchange ratio (H 1.22 ± 0.02; L 1.13 ± 0.01) in H were higher, and arterial oxygen saturation (H 86.0 ± 0.7; L 89.5 ± 0.8%) and arterial pH (H 7.202 ± 0.018; L 7.275 ± 0.019) in H were lower than in L. Peak heart rate (H 214 ± 3; L 211 ± 4 bpm) and pulmonary arterial temperature (H 41.1 ± 0.3; L 41.1 ± 0.3 °C) did not differ between groups. Peroxisome proliferator-activated receptor-γ coactivator-1α (PGC-1α) mRNA increased in both groups 4 h after the treadmill run (H 4.81 ± 0.71; L 2.77 ± 0.58 -fold) with H greater than L. Vascular endothelial growth factor (VEGF) mRNA increased 4 h after the treadmill run in H but not L (H 1.79 ± 0.26; L 1.17 ± 0.29 -fold).

Conclusions - The training programme of H ran less total distance but greater distance at higher intensity than L, presumably providing greater stimulation of aerobic and anaerobic energy pathways than did L. A single training bout with H induced greater adaptations in mitochondrial biogenesis and angiogenesis of skeletal muscle than with L.

Where applicable, the authors confirm that the experiments described here conform with the Physiological Society ethical requirements.

---

**PC06**

**Trunk muscle activation in back squat and hack squat at the same relative loads**

D. Clark¹,², M. Lambert³ and A. Hunter²

¹Fitness Dept., Irish Rugby Football Union, Dublin, Ireland, ²School of Sport Sciences, University of Stirling, Stirling, UK and ³Division of Exercise Science and Sports Medicine, Department of Human Biology, University of Cape Town, Cape Town, South Africa

The loaded barbell back squat (BS) (Fig. 1) is an established method for development of strength and power in lower limb (1,2). Trunk muscle activation (TMA) using surface electromyography (sEMG) in BS is novel and clarity on the role of BS in developing dynamic trunk strength and stability is required. BS performed on an unstable surface will result in greater TMA, but compromises the load and therefore primary purpose (1,2). TMA in BS is load sensitive (3) and greater in free barbell version than the more supported Smith machine squat. How does TMA in a more stable squat, hack squat (HS) (Fig. 2), at the same relative, but higher absolute load compare to BS? The centre of gravity of BS system, person and external load, must remain over base of support or feet (4) to prevent failure or injury. In HS the trunk is supported by a 45° angled board and feet are placed anterior to line force (4). Hypothesis, TMA in BS will be greater than HS at the same
relative loads but greater absolute load in HS. Aims of the study: 1) determine max strength in BS and HS, 2) compare TMA in BS and HS, and 3) assess TMA response to load increases in BS and HS. Ethical approval according to Helsinki Declaration (2013) was granted. 3 test sessions (n=10 males): 1) BS and HS 1 rep max (RM) test, 2) EMG test familiarization, 3) EMG tests for 3 reps of BS and HS at 65, 75, 85 and 95% of system mass max (SM). SM = 1RM + (0.886 x body mass) (kg), where 0.886 is body mass minus shanks. Kinematics measured by a linear transducer and sEMG (SENIAM guidelines) for rectus abdominus (RA), external oblique (EO), upper lumbar erector spinae (ULES) and lumbar sacral erector spinae (LSES). Vastus lateralis (VL) sEMG as reference lower limb muscle. sEMG was root mean square (RMS) processed. Mean RMS for each phase of BS and HS at 75, 85 and 95% SM were normalized to mean concentric BS RMS at 65% SM (5). Mean HS 1RM was 28.5 kg (18.24%) greater than BS, hence 4 test loads in HS were significantly higher than BS (F_{1, 9} = 19.94 p<0.01). Eccentric displacement was 21.5 cm less in HS than BS for 4 test loads. Force was higher in HS than BS at each load and increased with each load in both exercises. BS TMA was greater than HS for all muscles, both phases for all test loads. Difference was significant (p<0.05) in 14/24 instances (3 loads x 4 muscles x 2 phases). TMA increased with load in all muscles for both exercises and phases apart from HS LSES in eccentric phase. VL RMS was greater in BS than HS for all loads but only significant in concentric phase. There was a load effect for VL in both exercises. This study demonstrated a greater 1RM for HS vs BS for well-trained cohort. Despite higher absolute tests loads and force in HS, TMA was higher in BS. This study suggests the BS is an effective method of developing trunk strength and that TMA is sensitive to load in both BS (3) and HS.
Figure 1. Back squat
PC07

Dietary nitrate supplementation improves mean power during upper body resistive exercise

S. Pavlaki, R. Varnham and R. Ramsbottom

Sport & Health Sciences, Oxford Brookes University, OXFORD, UK

Dietary inorganic nitrate (NO$_3^-$) supplementation has been shown to improve maximal muscle power and exercise tolerance at high, but not low contraction velocities during lower body exercise (Coggan et al, 2014; Bailey et al, 2015). Supplementation also improves upper body performance (Peeling et al, 2015), however, it remains unclear whether NO$_3^-$ supplementation improves muscle power or exercise tolerance during 'all-out' upper body exercise. We tested the hypotheses that during all-out bench press exercise, acute NO$_3^-$ supplementation would improve performance by: i) increasing total work ii) prolonging time to exhaustion iii) increasing mean power.

Where applicable, the authors confirm that the experiments described here conform with the Physiological Society ethical requirements.
Eight men, age 26.4±3.1 years; height 1.79±0.06 m; mass 81.5±12.8 kg (mean±SD), consented to participate in a randomised, double-blind cross-over study, which had University ethical approval and followed the principles laid out by the Declaration of Helsinki. Volunteers responded to poster advertisements and were able to withdraw from the study at any stage without reason. During visits, participants arrived to the laboratory in the morning following an overnight fast. Diet was replicated between trials and foods high in NO3− were avoided. Following thorough familiarisation, participants returned to the laboratory on two occasions, separated by a minimum of seven days, during which they were instructed to perform bench press exercise (Smith machine) as fast as they could at 40% 1RM (one repetition maximum), and to continue the protocol to maximal volitional exhaustion. During the two experimental visits participants consumed either beetroot juice (BR; 13 mmol NO3−) or placebo (PL; NO3− depleted BR) (Beet It Sport, James White Drinks, UK) 2.5 hours before exercise. Blood pressure (BP) was measured using an automated sphygmomanometer (Dinamap 400 ProV) before ingestion, and again before exercise. Bench press performance was assessed from video analysis (30Hz) for time to exhaustion (s), total work (kJ), and mean power (W). Student’s t-tests were used to identify differences between BR and PL and a two-way ANOVA for BP (SPSS 22). There was no main effect of supplement on BP (120±8/70±6 vs.119±10/70±6 mmHg, BR vs. PL respectively), and there was no interaction effect for condition over time. There was no difference in time to exhaustion between BR (46.7 ± 6.4) and PL (45.7 ± 5.5 s), however, both total work performed (BR: 8.8 ± 2.5; PL: 8.2 ± 2.5 kJ; P<0.05) and mean power (BR: 188 ± 56; PL: 179 ± 58 W; P<0.01) were greater with BR compared to PL. The present results show increased total work and mean power with BR during all-out, upper body exercise, without any change in time to exhaustion. The physiological explanation for these findings remains unclear, but may relate to improvements in local muscle oxygen delivery, perfusion or extraction.


Volunteers who complied with the strict experimental protocol. 

Where applicable, the authors confirm that the experiments described here conform with the Physiological Society ethical requirements.
The effects of a 16 week aerobic exercise programme on cognitive function in people living with HIV

A.D. McDermott¹, C. Forde², M. Egana¹, J. Gormley² and C. Bergin³

¹Physiology, Trinity College Dublin, Dublin, Ireland, ²Physiotherapy, Trinity College Dublin, Dublin, Ireland and ³Infectious Diseases, St. James’ Hospital, Dublin, Ireland

Since the introduction of highly active antiretroviral therapy there has been a marked increase in the prevalence of HIV associated neurocognitive disorders (HAND). It has been suggested that higher levels of physical fitness are associated with higher levels of cognitive function in people living with HIV (Dufour et al. 2011). Furthermore, evidence from other clinical areas suggests that higher levels of physical fitness are associated with improved cognitive function (Erickson et al. 2011; Suzuki et al. 2013). This project aimed to investigate whether a 16 week exercise intervention could improve cognitive function in people with HIV. Thirteen participants were recruited from a pre-defined group of patients who had been previously screened for HAND in St. James’ Hospital, Dublin. Participants were randomised into two groups: an exercise group (n=6), that completed a 16 week supervised aerobic exercise programme training 2 to 3 times per week, and a control group (n=7) that received no intervention and continued with their routine care. Primary outcomes measured included cognitive function (Montreal Cognitive Assessment (MOCA) and the trail making tests A and B), aerobic fitness (modified Bruce protocol), sleep quality (Pittsburgh Sleep Quality Index; PSQI), metabolic profiles and anthropometrics. Higher levels of moderate physical activity and aerobic fitness were significantly correlated with higher cognitive function at baseline (P=0.04 and P=0.001 respectively). Despite an overall low adherence rate of 60% to the exercise programme, there was a tendency for a numerically larger improvement in short term memory in the exercise group compared to the control group. However, there were no significant improvements in global cognitive scores. In addition, significant improvements were recorded in daytime dysfunction, an important domain of sleep quality, in the exercise group following training compared to the control group (P<0.05). No significant improvements were seen in aerobic fitness or metabolic profiles after the intervention. In conclusion exercise may have beneficial effects on cognitive function and sleep quality in people with HIV. However, further research is warranted with larger sample sizes and adherence rates to allow for a more in depth investigation of the effects of exercise on cognitive function in this population.

Interaction between physiological and mechanical data to clarify elite sprint swimming performance

P. Morouço
Polytechnic Institute of Leiria, Marinha Grande, Portugal

Elite performance evaluation has been mainly conducted through physiological or mechanical approaches separately. However, it is constructive to gather those fields to understand the major factors that explain outstanding performances. That velocity is dependent on the maximal total energy expenditure corrected for body mass and the energy cost (C), being C associated with intra-cyclic variations of the horizontal velocity (dv) of the body. Theoretically, dv are the result of intra-cyclic variations of the horizontal force (dF) of the body. Although higher variations lead to lower performances, it is not known if and how dv and dF are related and their role for very high velocities. 23 elite swimmers were tested (males, 18.6±2.3 years of age; 1.79±0.09m of height; 69.9±9.2kg of body mass; 56.7±2.9s of 100m PB). On separate days, all-out 50m front crawl (26.7±1.50s) was performed to calculate dv by a speed-meter cable (Swimsportec, Hildesheim, Germany) attached to the swimmer’s hip, and a 30s all-out fully tethered swimming was completed to determine dF by a load-cell system (Globus, Codognè, Italy). Increase in blood lactate concentration (ΔBLa) was measured using a portable analyzer (Lactate Pro, Arkay, Japan). Heart rate was continuously recorded by a HR monitor (RS800CX, Polar Electro Oy, Kempele, Finland). Rate of perceived exertion (RPE) was assessed verbally (REF). SR (Hz) was determined using a portable SR counter (Seiko, Tokyo, Japan). ICC were between 0.94 (0.90–0.98) and 0.98 (0.96–0.99) for the measurements (n=8). Values are means ± S.D., compared by repeated measures. Both dv and dF exhibited similar patterns in the instantaneous curves; with very high different magnitudes (8.8±2.3% vs. 65.0±10.1%, p<0.05 respectively). There were no differences in ΔBLa, HR, RPE, or SR within the tests, with a very strong agreement of ΔBLa and SR (average differences were rather low, with limits of agreement (average±1.96 S.D.) ranging from −0.067 to 0.107 for SR and from −1.036 to 1.235 for ΔBLa). Thus, tethering the swimmer did not alter any physiological
or mechanical responses compared with free swimming of similar duration and intensity. $dv$ showed a high but non-linear relationship with swimming mean velocity ($r=-0.78$, $p<0.01$), whereas $dF$ presented a linear relationship ($r=-0.84$, $p<0.001$). Hence, $dF$ should be assessed for elite performance evaluations; higher $dF$ induced a higher $dv$, leading to lower performances, suggesting that higher variations leads to an increase in $C$ to overcome inertia and drag force. The present study showed that gathering the theoretical hypothesis with experimental data the demands of front crawl elite performance can be explained through a hybrid approach; ie. combining physiological and mechanical knowledge.

Funded by Fundação para a Ciência e a Tecnologia within the project UID/Multi/04044/2013.

Where applicable, the authors confirm that the experiments described here conform with the Physiological Society ethical requirements.

PC10

Loss of torque complexity during fatiguing submaximal isometric knee extensions in man is slowed by caffeine ingestion

J. Pethick, S. Winter and M. Burnley

School of Sport and Exercise Sciences, University of Kent, Medway, UK

The temporal structure, or complexity, of torque output is thought to reflect the adaptability of motor control and has important implications for system function, with high values endowing greater adaptability in response to alterations in task demand. Neuromuscular fatigue has been demonstrated to reduce torque complexity during repeated isometric knee extension contractions (Pethick et al., 2015); however, the mechanism(s) behind this fatigue-induced loss of complexity is not known. We hypothesised that caffeine, an ergogenic aid thought to act primarily through central mechanisms, would attenuate the fatigue-induced loss of torque complexity previously observed. Ten healthy participants performed, on separate days, intermittent isometric submaximal contractions at a target torque of 50% MVC, with a 60% duty factor (6 s contraction, 4 s rest), after having ingested either 6 mg.kg$^{-1}$ caffeine or the same amount of placebo one hour prior to the commencement of the contractions. Torque and surface EMG signals were sampled continuously. Complexity and fractal scaling of torque were quantified by calculating approximate entropy (ApEn) and the detrended fluctuation analysis (DFA) scaling exponent, $\alpha$. Global, central and peripheral fatigue were quantified using maximal voluntary contractions (MVCs) with femoral nerve stimulation. Values are means $\pm$ SEM, compared by ANOVA and $t$-test. Caffeine ingestion significantly increased time to task failure by $2.4 \pm 0.9$ mins ($P = 0.019$). Complexity decreased in both trials (decreased ApEn and increased DFA $\alpha$, both $P < 0.01$), as global, central and peripheral fatigue increased (all $P < 0.01$). However, the rate at which complexity
decreased was significantly lower following caffeine ingestion (ApEn, $-0.06 \pm 0.01$ vs. $-0.04 \pm 0.01$, $P = 0.014$), as were the rates of global ($-22.1 \pm 5.7$ vs. $-17.8 \pm 4.7$ N.m.min$^{-1}$, $P = 0.011$), central ($-5.7 \pm 1.3$ vs. $-3.7 \pm 1.1$ %min$^{-1}$, $P = 0.046$) and peripheral ($-8.2 \pm 2.1$ vs. $-6.5 \pm 1.6$ N.m.min$^{-1}$, $P = 0.043$) fatigue development. This slower loss of complexity and slower rate of fatigue development, in all its forms, following caffeine ingestion suggests that the mechanisms responsible for the loss of torque complexity and caffeine's ergogenesis are intrinsically linked. However, the slowing of fatigue in all its forms does not allow the identification of a single mechanism responsible for the loss of torque complexity. Instead, the loss of torque complexity could be the expression of an integrated response to neuromuscular fatigue, including both central and peripheral components.


Where applicable, the authors confirm that the experiments described here conform with the Physiological Society ethical requirements.

---

**PC11**

**The effects of beetroot Juice and sodium nitrate on muscle damage following eccentric exercise**

T. Clifford$^{1}$, G. Howatson$^{1}$, D. West$^{2}$ and E. Stevenson$^{2}$

$^{1}$Northumbria University, Newcastle Upon Tyne, UK and $^{2}$Newcastle University, Newcastle Upon Tyne, UK

Exercise-induced muscle damage (EIMD) is characterized by muscle pain, reduced muscle function and inflammation. It was recently shown that some of these indices can be reduced with acute beetroot juice (BTJ) supplementation (Clifford et al, 2015); however, the active compounds in BTJ responsible for these effects have not been elucidated. More specifically, whether these effects are mediated by nitrate or other phytonutrients (i.e., polyphenols) in BTJ has not been investigated. Thus, the aim of this study was to investigate the effects of BTJ and a nitrate only drink (sodium nitrate; SN) on EIMD. Using a double blind, independent groups design, 30 recreationally active males were randomly assigned to a BTJ ($n=10$), SN ($n=10$) or an isocaloric placebo (PLA; $n=10$) group. The BTJ and SN drinks were matched for nitrate content (~210 mg) and energy content. Drinks were consumed (2 x 250 ml) immediately, 24 and 48 h after performing 100 drop jumps. To assess muscle damage, maximal isometric voluntary contractions (MIVC), countermovement jumps (CMJ), reactive strength index (RSI), pressure-pain threshold (PPT) creatine kinase (CK) and high sensitivity C-reactive protein (hsCRP) were measured pre, immediately post, 24, 48 and 72 h following the drop jumps. Values are mean±SD; statistical analysis was carried out with a mixed model ANOVA. The exercise bout caused a significant decrease in PPT across all groups ($P = 0.001$); however, the decrease was attenuated with BTJ compared to SN and PLA.
Poster Communications

throughout the 72 h measurement period (P = 0.043). PPT had recovered to baseline values in the BTJ group by 72 h (104.3±25.9%) but remained depressed in both the SN (94.1±16.0%) and PLA groups (91.2±19.0%). Muscle function (MIVC, CMJ and RSI) was reduced following exercise by ~15-25% and did not recover to baseline by 72 h in all groups (P < 0.05); no group differences were observed (P > 0.05). Serum CK increased after exercise and peaked at 24 h post but no group differences were present (P> 0.05). hsCRP levels were unaltered by the exercise protocol (P> 0.05). These data suggest that BTJ supplementation might be a useful strategy to attenuate muscle pain associated with EIMD, and that any analgesic effects are likely due to phytonutrients in BTJ other than nitrate, or interactions between them. Further research is needed to clarify the potential differing effects of SN and BTJ on neuromuscular recovery.

Where applicable, the authors confirm that the experiments described here conform with the Physiological Society ethical requirements.

PC12

Ketone ester drinks increase blood ketone levels more effectively than ketone salt drinks

B.J. Stubbs, R. Evans, K. Clarke and P.J. Cox

Department of Physiology Anatomy and Genetics, Oxford University, Oxford, UK

Introduction: Ketone bodies (KB) are oxidative fuel substrates and metabolic signals produced in response to starvation or a high fat, low carbohydrate diet. KB may provide a superior fuel source to athletes [1]. We developed a ketone ester (KE) that, when consumed as a drink, rapidly increased circulating KB [2]. Ketone salt (KS) drinks are an alternative to achieve nutritional ketosis [3]. However, the comparative efficacy of KE and KS drinks to raise blood KB is unknown. The aim of this study was to compare blood KB levels after body-weight adjusted, equimolar amounts of KB were consumed in KE and KS drinks.

Methods and Results: Following favourable ethical review, healthy, non-obese volunteers (n = 5) completed a 4-armed randomized, cross-over study. Following an overnight fast, volunteers consumed a weight-adjusted dose of β-hydroxybutyrate (BHB) (low- 1.6 mmol/kg OR high- 3.2 mmol/kg) in KS or KE, artificially flavoured and made up to 300 ml using water. Blood samples were obtained via an IV catheter at baseline (BL) and at regular intervals post-drink. Samples were analyzed for D-BHB. Volunteers completed questionnaires to record any GI/systemic symptoms experienced. D-BHB values are means ± SEM. Symptoms are number reported per 100 possible reports. Repeated measures ANOVA with Tukey Post Hoc corrections were performed. Significance was taken at p<0.05.

Consumption of both KE and KS drinks increased the blood levels of D-BHB. Peak D-BHB concentration (D-BHB Cmax) was significantly greater following the high dose of KE (3.0 ± mM) vs. low dose KE (1.5 ± mM) and vs. both high (1.2 ± mM) and low (0.9 ± mM)
Poster Communications

doses of KS. There were no significant differences in D-BHB C$_{\text{max}}$ between low dose KE, and low and high doses of KS. D-BHB uptake (AUC) was significantly higher following high dose of KE ($417 \pm 62$ mM.min) vs. all other groups, but there were no differences between low dose KE ($166 \pm 24$ mM.min), and low ($117 \pm 21$ mM.min) and high ($170 \pm 7$ mM.min) doses of KS. GI symptoms reported were significantly higher with high dose of KS (10/100 possible) than low doses of both KS (2.6/100 possible) and KE (3.4/100 possible), however there were no significant differences between the high dose of KE (6.5/100 possible) and all other groups.

Conclusions: Increasing KE dose results in greater D-BHB C$_{\text{max}}$ and AUC; however this is not seen following KS drinks. Long term KS consumption may result in clinical complications due to the inorganic ion load in each drink [4], furthermore we saw that high doses of KS cause a greater incidence of GI symptoms. Therefore we conclude that KE drinks are a more effective method to elevate D-BHB in athletes than KS drinks, with fewer acute side effects.


*Where applicable, the authors confirm that the experiments described here conform with the Physiological Society ethical requirements.*

**PC13**

**Muscle mitochondrial dysfunction in Type 2 diabetes likely results from a decline in total mitochondrial DNA copy number**

D. Constantin-Teodosiu$^1$, D. Constantin$^1$, L.B. Verdijk$^2$, K. Tsintzas$^1$, L. van loon$^2$ and P.L. Greenhaff$^1$

$^1$Life Sciences, Nottingham University Medical School, Nottingham, UK and $^2$Health, Medicine and Life Sciences, Movement Sciences, Maastricht University, Maastricht, Netherlands

Type 2 diabetes (T2D) is associated with excess energy intake and physical inactivity. Intrinsically linked to these events are deficits in muscle total mitochondrial volume and/or function (Kelley et al., 2002), but whether this reflects a lower muscle mitochondrial DNA (mtDNA) copy number or simply a muscle deconditioning is debated. We therefore quantified maximal oxygen consumption ($\text{VO}_{2\text{max}}$), mtDNA copy number (RQ-PCR) and mitochondrial enzyme activities (GluDH, CS, $\beta$-HAD; spectrophotometrically) in muscle biopsies from older age-matched, male
volunteers: healthy trained (57.4 ± 0.9 yrs, n=10), healthy sedentary (60.0 ± 2.0 yrs, n=10), and T2D patients (58.9 ± 2.0 yrs, n=10). Ethical approval was granted before subject’s consent was obtained.

VO$_{2\text{max}}$a ISIb mtDNA GluDHc CSc β-HADC
Trained 3.8±0.1*# 133±24 ** 1461±52 **### 9.8±0.9 **# 84.4±9.5 **# 32.6±3.2**#
Sedentary 3.2±0.2 86±12* 749±35*** 6.9±0.4 51.9±7.0 21.3±2.5
T2D 2.9±0.2 48±6 454±59 5.6±0.6 42.6±2.3 20.9±3.6

aL min$^{-1}$; bmg L$^{-2}$ (mmol mU min)$^{-1}$; cmmol min$^{-1}$mg$^{-1}$ protein, *, **, ***Significantly different from T2D (P<0.05, P<0.01 and P<0.001); #, ###Significantly different from sedentary (P<0.05, P<0.001). All values in text and Table represent mean±SEM. Statistical differences detected using ANOVA.

Except for Insulin Sensitivity Index (ISI), no differences in mitochondrial enzymatic markers were detected between older healthy sedentary and T2D (Table). However, both were markedly different from older trained volunteers. The number of mtDNA copy number in the older trained group was significantly greater than in the older untrained and T2D groups (P<0.001). Furthermore, the mtDNA copy number in the older untrained group was significantly greater than in the T2D group (P<0.001). This suggests that any apparent muscle mitochondrial dysfunction in T2D likely results from a decline in total mtDNA copy number.


Where applicable, the authors confirm that the experiments described here conform with the Physiological Society ethical requirements.

PC14

The effect of type 2 diabetes in muscle deoxygenation during ramp incremental cycling exercise

N. Gildea$^1$, J. Rocha$^1$, S. Green$^3$, D. O’Shea$^2$ and M. Egana$^1$

$^1$Physiology, Trinity College Dublin, Dublin, Ireland, $^2$Endocrinology, St Columcille’s and St Vincent’s Hospitals, Dublin, Ireland and $^3$School of Science and Health and School of Medicine, University of Western Sydney Australia, Sydney, NSW, Australia

Defects in functional exercise capacity in patients with type 2 diabetes mellitus (T2DM) have been consistently reported, with impairments in maximal exercise performance of ~20% that are independent of obesity, and present in the absence of clinically apparent cardiovascular disease. Whilst the precise mechanisms for this abnormal exercise response remain to be elucidated, both central and peripheral factors have been identified as potential contributors (Green et al, 2015). In the present study we tested the hypothesis that T2DM alters the profile of muscle fractional O$_2$ extraction (estimated using deoxygenated haemoglobin) during incremental cycle exercise. Eight middle-aged participants (6 men, 2 women) with T2DM (46.85±7.58yrs; 31.68±5.76kg/m$^2$) and eight healthy controls (6 men, 2 women) (42.33±7.56yrs; 30.4±2.22kg/m$^2$) matched for age and body mass...
index respectively, performed a ramp incremental cycling test to exhaustion in an upright position. Exercise was performed initially for 2-min at 10W, followed by 15 W/min (females) or 25 W/min (males) increments on an electrically braked cycle ergometer, with pedal frequency held constant at an individually selected rpm. Pulmonary oxygen uptake (VO₂) was measured on a breath-by-breath basis using an online metabolic system. The rate of muscle deoxygenation (i.e. deoxygenated haemoglobin concentration, Δ[HHb]) profiles of the vastus lateralis (VL) muscle were continuously made with near infrared spectroscopy (NIRS) and analysed with a double linear model. Values are means ± SD, compared by a paired t test. Normalised VO₂peak was significantly (P = 0.047) reduced in individuals with T2DM compared with their respective non-diabetic counterparts (24.52 ± 4.15 vs 29.52 ± 4.99), representing a 17% reduction in peak exercise capacity. The first slope of the double linear regression function used to establish the dynamic adjustment of [HHb], was significantly (P = 0.038) larger in participants with T2DM than controls (1.35 ± 0.17 vs 1.08 ± 0.35). Such findings are indicative of a greater rate of oxygen extraction for a given increase in VO₂, suggesting that a reduced O₂ delivery is an important underlying cause of exercise intolerance during a maximum graded test in T2DM.


Where applicable, the authors confirm that the experiments described here conform with the Physiological Society ethical requirements.

Does age affect motor sequence learning ability?

M.K. Fleming, N. Lazarus and D. Newham

Centre of Human and Aerospace Physiological Sciences, King’s College London, London, UK

Healthy ageing is typically associated with a decline in cognitive and motor abilities and older adults may show reduced or slower motor sequence learning than younger adults (Boyd et al., 2008; Zimerman et al., 2013). This study aimed to examine the effect of age on an explicit motor sequence learning task. Healthy adult humans (n=25) aged 25-85 years performed a motor sequence learning task with the non-dominant (left) hand requiring movement of a computer mouse from a central square to illuminated targets on a computer monitor. Participants were informed of the presence of a repeated sequence of movements and encouraged to anticipate target appearance. After familiarisation, a sequence of 10 movements was repeated 25 times followed by a random sequence. Onset time (OT) was recorded as the time from target illumination to the cursor leaving the central square. Initial OT (i.e. reaction to target illumination) did not differ between older (>50 years) and younger (< 45 years) adults (t-test, p = 0.38) and there was no correlation between age and initial OT (Pearson correlation, p = 0.13). OT area
under the curve (OT AUC) was significantly better for younger adults than older (p = 0.04) and there was a significant moderate correlation between age and OT AUC (Fig. 1A, p = 0.01) suggesting reduced rate of learning with age. However, when OT AUC was divided into bandwidths of functional equivalence (Lazarus and Harridge, 2010) using five categories (1 = OT AUC < 10, 2 = 10-15, 3 = 15-20, 4 = 20-24, 5 >24) a spread of ages across each category can be seen (Fig. 1B). There was no difference between younger and older adults for the specificity of sequence learning (OT difference between trained and untrained sequence, p = 0.38). These results suggest that motor reactions and sequence learning with the non-dominant hand may not be impaired in healthy older adults and highlights the complexity of the relationship between age and motor function.

Fig. 1. A. Onset time (OT) area under the curve (arb. units) as a function of age of participant. Values <24 indicate learning of the movement sequence. B. Age of participant as a function of OT area under the curve grouping (1= excellent learning: OT AUC <10, 5 = no learning: OT AUC >24), showing a spread of ages for each grouping.


Thank you to Roger Woledge for writing the Matlab programme and Tony Christopher and Lindsey Marjoram for technical support. MKF is supported by a King’s College London doctoral scholarship and a project grant from the Stroke Association awarded to DJN.

Where applicable, the authors confirm that the experiments described here conform with the Physiological Society ethical requirements.

---

**PC16**

**A novel homozygous mutation in the VHL gene in man is associated with exaggerated cardiopulmonary responses to acute hypoxia and limited exercise capacity**

F. Formenti1,2,3, F. Della Ragione4, P. Robbins2 and S. Perrotta5

1Centre of Human and Aerospace Physiological Sciences, King’s College London, London, UK, 2Department of Physiology, Anatomy and Genetics, University of Oxford, Oxford, UK, 3Nuffield Division of Anaesthetics, University of Oxford, Oxford, UK, 4Department of Biochemistry, Biophysics and General Pathology, Second University of Naples, Naples, Italy and 5Dipartimento della Donna, del Bambino e di Chirurgia Generale e Specialistica, Second University of Naples, Naples, Italy

The hypoxia-inducible factor (HIF) transcriptional pathway is fundamental for the regulation of cellular function in hypoxia [1]. Genetic mutations of the HIF pathway favoured Tibetans’ adaptation to life at high altitude [2], but other mutations, e.g. in the Von Hippel-Lindau (VHL) gene, can compromise the HIF pathway function, and be associated with polycythaemia, abnormal cardiopulmonary function [3, 4] and metabolism [5]. A patient homozygous for a novel C>A mutation on VHL (Val74Val) presented with lower than normal levels of VHL protein and polycythaemia. We explored this patient’s physiological response to acute hypoxia and, separately, to exercise.

Methods - The patient’s cardiopulmonary physiology was studied at rest at sea level (baseline) and in a hypoxic chamber at a simulated altitude of about 3,500 m. Respired gases were sampled continuously, and end-tidal partial pressure of carbon dioxide (ETCO₂) was kept close to the patient’s air-breathing value throughout the protocol. We monitored heart rate, arterial oxygen saturation, ventilation, pulmonary arterial systolic pressure (PASP) and cardiac output, and averaged data over 4 minutes. Results from 15 control participants who took part in comparable studies [3, 4] are presented for comparison.
The patient’s exercise capacity was measured with an incremental exercise test on a cycle ergometer, where the workload was increased by 20 W per min until exhaustion (tested twice). We measured venous blood lactate at the end of each workload, and respiratory gases continuously. Data were averaged for each min of exercise, and compared with results from control participants (n=6) [5]. All values presented are mean ± S.D.

Results - Table 1 shows the results from the test of cardiopulmonary responses to acute hypoxia. During air breathing conditions at baseline, the patient’s end-tidal partial pressure of oxygen (ETO₂) was high and ETCO₂ low. The patient’s PASP and cardiac output were elevated at baseline, and showed a marked increase in response to hypoxia.

Figure 1 shows the patient’s responses to the exercise test to exhaustion on the cycle ergometer. The patient showed a limited exercise capacity, associated with a low peak value for lactate in venous blood, and a greater than normal increase in ventilation for equivalent work rates. ETCO₂ remained low throughout the exercise protocol. Control participants stopped exercising later in the protocol (~240 W; data not shown).

Conclusions - These findings highlight the role of the HIF pathway in regulating human physiology at whole organism level.

<table>
<thead>
<tr>
<th></th>
<th>End Tidal O₂ (mmHg)</th>
<th>End Tidal CO₂ (mmHg)</th>
<th>PASP (mmHg)</th>
<th>Cardiac Output (l min⁻¹)</th>
<th>Heart Rate (beats min⁻¹)</th>
<th>Ventilation (l min⁻¹)</th>
<th>Saturation (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline patient</td>
<td>120 ± 5</td>
<td>25 ± 3</td>
<td>26 ± 2</td>
<td>6.6 ± 0.3</td>
<td>63 ± 9</td>
<td>10 ± 3</td>
<td>87 ± 1</td>
</tr>
<tr>
<td>Baseline control (n=15)</td>
<td>100 ± 4</td>
<td>39 ± 3</td>
<td>20 ± 2</td>
<td>4.4 ± 0.7</td>
<td>59 ± 11</td>
<td>11 ± 3</td>
<td>96 ± 3</td>
</tr>
<tr>
<td>Hypoxia patient</td>
<td>46 ± 1</td>
<td>26 ± 1</td>
<td>41 ± 2</td>
<td>9.2 ± 0.3</td>
<td>83 ± 7</td>
<td>20 ± 4</td>
<td>66 ± 1</td>
</tr>
<tr>
<td>Hypoxia control (n=15)</td>
<td>50 ± 1</td>
<td>39 ± 2</td>
<td>26 ± 3</td>
<td>6.6 ± 1.0</td>
<td>71 ± 11</td>
<td>18 ± 9</td>
<td>84 ± 4</td>
</tr>
</tbody>
</table>

*control n=11
Where applicable, the authors confirm that the experiments described here conform with the Physiological Society ethical requirements.
Influence of priming exercise and type 2 diabetes on oxygen uptake and muscle deoxygenation kinetics during submaximal exercise

J. Rocha¹, N. Gildea¹, D. O’Shea², S. Green³ and M. Egana¹

¹Physiology, Trinity College Dublin, Dublin, Ireland, ²Endocrinology, St Columcille’s and St Vincent’s Hospitals, Dublin, Ireland and ³School of Science and Health and School of Medicine, University of Western Sydney, Sydney, NSW, Australia

Middle aged and young adults with uncomplicated type 2 diabetes (T2D) show a slowed adjustment of oxidative metabolism during metabolic transitions (i.e. oxygen uptake, VO₂ kinetics) due to progressive limitations of both O₂ delivery and utilisation. Priming exercise (PE) has been shown to increase the speed of adjustment of oxidative metabolism during subsequent moderate-intensity step transitions in healthy adults presenting initially slow VO₂ kinetics. We tested the hypothesis that PE would increase the speed of the adjustment of the primary phase (τₚ) of VO₂ during moderate intensity cycling in T2D and that this would be due to a better matching of O₂ delivery to utilisation. Ten middle-aged participants with uncomplicated T2D (50.7 ± 9.0 years, 30.4 ± 5.3 kg/m²; 7 men / 3 women) and 10 non-diabetic (ND) controls (44.4 ± 9.6 years, 31.1 ± 4.1 kg/m²; 7 men / 3 women) were recruited. Participants completed four bouts of constant-load cycling at 80% of their ventilatory threshold previously established during a ramp incremental test. Two of these constant-load bouts were completed without priming exercise (ModA) and two bouts were undertaken with prior heavy intensity priming exercise (ModB). VO₂ kinetics was calculated from continuously measured breath-by-breath data, while the rate of muscle deoxygenation (i.e., deoxygenated hemoglobin, HHb) and tissue oxygen saturation (i.e., tissue oxygenation index) were continuously measured by Near–infrared spectroscopy (NIRS) at the vastus lateralis muscle. The time constant of the primary phase, τₚ, was significantly slower in T2D, but PE significantly (P<0.05) reduced τₚ in both groups by a similar magnitude (T2D, 48.29 ± 11.5 vs. 35.9±13.0 s; ND, 34.0 ± 9.6 vs. 26.8 ± 10.5 s). The adjustment of deoxygenated hemoglobin (HHb) did not show any differences between groups but its amplitude was increased after PE (P=0.036). Total tissue oxygenation at baseline and end of exercise was lower in T2D (P<0.05), however, PE increased tissue oxygenation index at baseline (p=0.002) and the delta values at the end of exercise (p=0.001) in both groups. The HHb/VO₂ ratios (20-120s) were reduced after PE (T2D, 1.12 ± 0.12 vs 1.07 ± 0.12; ND, 1.03 ± 0.13 vs 1.00 ± 0.12; P=0.038). These preliminary data support that in middle-aged adults with T2D, priming exercise prior to moderate-intensity exercise, beneficially affects the speed of adjustment of oxidative metabolism, possibly due to the partial improvement in the transient mismatch of muscle O₂ delivery relative to utilisation.

The authors would like to thank all the volunteers for their participation in this study.

Where applicable, the authors confirm that the experiments described here conform with the Physiological Society ethical requirements.
Awareness and knowledge of prevention and basic rehabilitation protocols of sports injuries among senior school athletes in Sri Lanka

S.S. Jayalath¹, A. Karunaratne², M. Fonseka¹ and N. Silva³

¹Physiotherapy, International Institute of Health Sciences, Welisara, Sri Lanka, ²Health and life sciences, Coventry University, Coventry, UK and ³Medical officer, Ministry of Health, Colombo, Sri Lanka

Problem Statement: Sports injuries are gradually increasing all over the world. School athletes are the first stepping stone in improving knowledge and skills in the community, therefore understanding and improving their knowledge is of great importance. Furthermore school athletes are the potential group that will make up the senior professional athletes population in the future. Prevention of injuries and proper first aid helps minimize injuries and reduce further complications. Therefor evaluation of the existing knowledge and practices of school athletes regarding injuries and their prevention is an essential exercise. This study will help to determine the extent of their knowledge in prevention of injuries and basic first aid.

Objective: To identify the knowledge of prevention and rehabilitation of sports injuries among senior school athletes in Sri Lanka.

Methods: A descriptive cross sectional study on senior school athletes in Colombo was done using a sample of 150 conveniently selected students, using a self-administered questionnaire with 10 close ended questions and analyzed using descriptive and analytical statistics. Ethical clearance was obtained from the Ethics Review Committee of the International Institute of Health Sciences, Sri Lanka.

Results: Out of 150 participants, only 45 students have adequate knowledge of cryotherapy, 51 have basic knowledge of relieving cramps, 69.3% continue stretching though they have pain, 67.3% are unaware of proper bandaging protocols, 39.3% understand splinting and its uses and 26.7% are well informed on the necessity of CPR. Whereas, out of the 150 students, 80 students are aware of emergency wound care, 64% know standard first aid for ankle sprains, 75.3% are aware of the purpose of vapo-coolant spray, and 99.3% perform warmup exercises and 96% practice cool down exercises.

Conclusions: Senior school athletes perform warm up and cool down exercises which is an integral part of injury prevention, but when considering basic first aid and post injury rehabilitation there are many aspects in which majority of the athletes are lacking in knowledge and training. Provision of knowledge on prevention of injuries and complications of injuries would help to upgrade their performance. It is vital to improve their knowledge in these areas to prevent further complications as well. Furthermore by considering all above factors it is necessary to establish a
system to train and improve their knowledge serially. Additionally, policy changes may be needed to address this lack of knowledge in management of these injuries when they occur.

Key words: Senior School Athletes, Sport Injuries, Prevention.

Where applicable, the authors confirm that the experiments described here conform with the Physiological Society ethical requirements.

---

**PC19**

**Commonly used activating solutions cause different levels of specific force in chemically skinned human muscle fibres**

M. Kalakoutis¹, A. Atkinson², J. Ochala¹ and S.D. Harridge¹

¹Centre of Human and Aerospace Physiological Sciences, King’s College London, London, UK and ²Centre for Biomolecular Spectroscopy and Randall Division of Cell and Molecular Biophysics, King’s College London, London, UK

Specific force (SF) represents a muscle’s contractile quality and is the peak isometric force normalised to cross-sectional area (CSA). There is large variance in published SF measurements from human skinned muscle fibres of young, healthy individuals, reduced only in part when methodological differences between studies are accounted for (Kalakoutis et al., 2014). Despite research on the effects of different chemical substrates on the mechanical properties of skinned fibres, experimental solutions used differ between research groups. The aim was to quantify the effect of this methodological difference, with emphasis on SF production.

Human Vastus Lateralis muscle fibres (n = 96) were obtained from a biopsy sample following local anaesthesia (2% lidocaine) in one young, healthy, male. Fibres were chemically skinned and exposed to two different activating solutions, A and B, in a random order. SF was measured at 15°C and time to half peak tension (t₅₀) was calculated as an indication of contraction kinetics. Three differences between solutions A and B were the uses of:

1) Imidazole (A) or Tes (B)
2) Glutathione (GL) (B only)
3) Potassium Chloride (KCl) (A) or Potassium Propionate (K-prop) (B).

The impact of each difference on skinned fibre contraction was isolated by making new solutions which differed in only one chemical constituent. A paired t-test assessed significance (p<0.05) of mechanical results (mean ± SD). ¹H nuclear magnetic resonance spectroscopy (¹H NMR) monitored potential formation of new compounds by reaction of Imidazole or Tes, which could affect SF.

A significantly higher SF and shorter t₅₀ was measured from the same fibres in solution B (109.8 ± 45.3 kPa; 1.5 ± 0.9s) compared with solution A (75.8 ± 43 kPa; 9.4 ± 4.4s). Isolating the effects of individual chemical components showed SF was 15.4 ± 7.7% higher (p<0.05) in a solution containing an optimum concentration of Tes (60mM), not Imidazole (20mM). The t₅₀ was shorter (p<0.05) in solution
containing GL (2.3 ± 1.1s) compared to without GL (5.8±2.9s) and in a solution containing K-prop (1.5 ± 1.4s) compared with a similar solution containing KCl (4.0 ± 3.0s). 1H NMR spectra corresponded to the compounds expected based on each solution’s composition, with no indication of reaction products. The higher SF elicited in solution B was largely due to the use of Tes instead of Imidazole. The shorter t_{50} in solution B was partly accounted for by a lower Cl⁻ concentration due to the use of K-prop instead of KCl and by the use of GL. 1H NMR experiments could not measure effects on ionic strength or [Mg^{2+}] so these remain possible mechanisms of the higher SF elicited by solution B.

These findings show that the use of different experimental solutions contributes substantially to the disparity of SF measurements reported by different publications studying human skinned fibres.


Where applicable, the authors confirm that the experiments described here conform with the Physiological Society ethical requirements.

---

PC20

Effects of training on pulmonary function amongst Sri Lankan national level athletes

K.U. Wijayasiri

sports and exercise medicine unit, colombo south teaching hospital, Dehiwala, Colombo, Sri Lanka, Colombo, Sri Lanka

Introduction - Poor performance of Sri Lankan athletes in the international arena is observed despite regular training. Performance depends on the physical fitness and technical training. Although techniques are addressed, a player’s physical fitness is not optimized by the present training programs.

Objective - To determine the status of pulmonary functions amongst Sri Lankan national level athletes in comparison to matched controls.

Methodology - National level athletes (n = 63) engaged in resistance and endurance sports were studied. Baseline data were collected by a questionnaire and clinical examination. Pulmonary functions were assessed by a Vitallograph spirometer. Results were compared with age, height, weight and gender matched controls (n= 63). Data were analyzed using SPSS version 16 statistical package.

Results - Inspiratory function as indicated by the Forced Inspiratory Vital Capacity (FIVC), Forced Vital Capacity (FVC) and Forced Expiratory Volume in 1st second (FEV₁) were significantly higher amongst the athletes (p< 0.05). The small air way function as determined by mid stream Forced Expiratory Flow (FEF_{25-75%}) of the athletes was similar to the controls (p>0.05). The expiratory muscle efficiency as
indicated by Peak Expiratory Flow Rate (PEFR) and FEV1/FVC ratio was not significantly different between the athletes and the controls (p>0.05).

Discussion - Better training should be associated with an optimal improvement of respiratory function; ie. Increasing the depth of breathing by increasing the Tidal volume and Vital Capacity. In order to achieve this both inspiratory and expiratory capacities have to be increased significantly. The results indicate that the respiratory efficiency of the athletes had not optimally improved with training.

Conclusion - The study concludes that training programs for the athletes must consist of exercise schedules to optimize the strength of respiratory muscles. This will achieve optimal pulmonary function amongst athletes. Improvement of pulmonary function may in turn promote better performance of athletes at competition.

Key words - National athletes, pulmonary function tests, respiratory muscles, exercise training, physical fitness.


José et al, 2001 Inspiratory Capacity, Dynamic Hyperinflation, Breathlessness, and Exercise Performance during the 6–Minute-Walk Test in Chronic Obstructive Pulmonary Disease. American Journal of Respiratory and Critical Care Medicine, Vol. 163, No. 6


Sport Associations and the Players: Athletics, Badminton, Football, Cricket and Rugby.

All the Academic staff and Non-Academic staff: Department of Physiology, Faculty of Medical Sciences, University of Sri Jayawardenepura, Nugegoda, Sri Lanka.

All the Doctors and other staff: Sports Medicine Unit, Colombo South Teaching Hospital, Kalubowila, Colombo, Sri Lanka.

Where applicable, the authors confirm that the experiments described here conform with the Physiological Society ethical requirements.
Body image perception in association with rigid and flexible dieting in athletes and non-athletes

A. Vlahoyiannis, I. Papasotiriou and A. Nifli

Technological Educational Institute of Thessaly, Department of Nutrition & Dietetics, Karditsa, Greece

Body image imposes or justifies eating patterns. Structured eating behaviours have been shown to correlate with BMI (1), eating disorders (1) and weight loss outcome (2). However, their relationship with perception and distortion of body image has not been investigated. The current study included 92 people, 68 males (34 athletes / 34 non-athletes) and 24 females (8 athletes/ 16 non-athletes). We evaluated anthropometric data and estimated body composition through skinfold measurement. Quantitative data of perceived and intentional body image were obtained by self-assessment with Somatomorphic Matrix software (3). The control of dietary restraint was assessed with FC12 and RC16 questionnaires (4). Statistical analysis revealed significant differences for actual and perceived body image in non-athletes. More specifically, women non-athletes were found to overestimate body fat and FFMI ($t(15) = 3.741, p = 0.002, t(15) = 6.309, p = 0000$ respectively), while men non-athletes underestimated FFMI ($t(33) = -2.604, p = 0.14$). Flexible and rigid dieting strategies were equally adopted by study subgroups, and correlated significantly ($r(91) = 0.649, p <0.001$). Classification as mainly flexible (score > 5 only in FC12), mainly rigid (score > 7 only in RC16), highly-structured (score > 5 in FC12 and > 7 in RC16) and non-structured (score < 5 in FC12 and < 7 in RC16) dieters and application of one-way ANOVA revealed statistically significant differences for the nonconformities of actual and perceived % body fat ($F(3,88) = 2.583, p = 0.058$) and FFMI ($F(3,88) = 6.334, p = 0.001$), as well as for the nonconformities of actual and intentional % body fat ($F(3,88) = 3.068, p = 0.032$) and intentional FFMI ($F(3,88) = 4.913, p = 0.001$). Further application of Hochberg post-hoc test revealed that flexible dieters presented lower discrepancy for actual and perceived % body fat than highly-structured dieters ($-3.3442 \pm 1.2071$ vs $1.3406 \pm 6.1629, p = 0.45$ respectively). In addition, in flexible dieters perceived and actual FFMI were closer than in non-structured dieters ($-1.2857 \pm 2.79966$ vs $1.3477 \pm 2.6448, p = 0.005$ respectively), and the same was calculated for intentional and actual FFMI ($0.8489 \pm 3.32429$ vs $4.2620 \pm 3.6, p = 0.002$ respectively). In contrast, rigid dieters tended to underestimate their FFMI compared to non-structured dieters (-$5.1615 \pm 3.15271$ vs $1.3477 \pm 2.6446, p = 0.018$) and to aim to rather low % body fat than non-structured dieters ($-18.32 \pm 4$ vs $-2.9044 \pm 6.8, p = 0.035$ respectively). Our data suggest that participation in athletic activities may prevent body image distortion, while dietary strategies do associate with more accurate body image perception and body image dissatisfaction.


Where applicable, the authors confirm that the experiments described here conform with the Physiological Society ethical requirements.

PC22

The influence of the Female Athlete Triad on bone quality in elite endurance runners

J. Coulson, A. Ireland, H. Degens and J. McPhee

School of Health care Science, Manchester Metropolitan University, Manchester, UK

Elite female athletes have exceptionally high physical activity levels. The physiological stresses associated with high exercise can disrupt normal homeostatic processes, altering menstrual cycles and energy balance, leading to a condition known as The Female Athlete Triad. The aim of this study was to examine bone and muscle characteristics of female elite-level endurance runners compared with age-matched controls. The study received ethical approval and all participants provided written consent. Controls (C) (n=15), eumenorrheic athletes (EA) (n=15) and amenorrheic athletes (AA) (n=14) completed dual energy X-ray absorptiometry (DEXA) and peripheral quantitative computed tomography (pQCT) scanning, three-day food diary, magnetic resonance imaging and muscle function testing. The amenorrheic athletes had 11.4% greater endochondral circumference of the radial diaphysis than controls. At the radial epiphysis EA had 14% greater total area than C, but the AA and C were similar. At the tibia diaphysis, the EA had a greater total area, cortical area and periosteal circumference than C (13.5,14.2 and 7.06% difference respectively). Similarly, the AA tibia diaphysis total area and periosteal circumference were greater than C (18 and 8.9% difference respectively), although EA had a 13.8% greater cortical thickness than AA at the tibia diaphysis. DEXA results (g/cm²) highlighted significant differences between C and AA at sites of trunk (0.91±0.16 for C vs 0.82±0.22 for AA), spine (1.05±0.24 vs 0.92±0.33) and lumbar spine (L1-4) (1.19±0.28 vs 1.04±0.33) (p<0.05). At the pelvis significant differences were found between C and EA, and between EA and AA (1.11±0.25 C, 1.14±0.23 EA and 0.99±0.093 AA; all p<0.05). Both the AA and EA had significantly
higher energy intake per day than controls (p=0.008 and p=0.001, respectively), with a trend towards higher calorie intake in EA than AA. The AA consumed significantly less protein than C (p=0.015). The EA consumed significantly more protein (p=0.043) and more fat than C (p=0.024). Muscle size and strength were similar across all groups. These results show that amenorrheic female athletes can have wider and thinner bones than eumenorrheic athletes and controls and highlight the importance of screening for the Female Athlete Triad.

Acknowledgements: Dr McPhee receives funding support from Life Long health and Wellbeing nr: MR/K025252/1 and MR/K024973/1

Where applicable, the authors confirm that the experiments described here conform with the Physiological Society ethical requirements.

PC23

GFP-lentivirus transduced human primary skeletal muscle-derived fibroblasts retain their potential for adipogenic transdifferentiation

O. Jaka\textsuperscript{1}, C.C. Agley\textsuperscript{1,2}, F.C. Lewis\textsuperscript{1}, N. Lazarus\textsuperscript{1}, G.M. Ellison-Hughes\textsuperscript{1} and S.D. Harridge\textsuperscript{1}

\textsuperscript{1}Centre of Human \& Aerospace Physiological Sciences, King’s College London, London, UK and \textsuperscript{2}Cambridge Stem Cell Institute, University of Cambridge, Cambridge, UK

Fatty degeneration in skeletal muscle is a hallmark of many myopathies, sarcopenia, obesity and type-2 diabetes. It has been shown that human skeletal muscle fibroblasts (but not the myogenic cells) have the potential for transdifferentiation into adipocytes in culture, suggesting that these cells may be the cause of adipocyte accumulation in muscle (1). In order to study the transdifferentiation potential of these cells in vivo (xenotransplantation), it is important to genetically label the fibroblasts before transplanting them into the host species and to confirm that they still retain their potential for adipogenic transdifferentiation. In this study we have sought to transduce human primary skeletal muscle fibroblasts with a GFP lentivirus and determine if the transdifferentiation potential of human muscle-derived primary fibroblasts is retained.

Following local anaesthesia (2\% lidocaine), a muscle biopsy sample was obtained from the \textit{vastus lateralis} muscle of a healthy, young, female subject (aged 20 years). Following isolation and expansion, cells were purified by immuno-magnetic cell-sorting using CD56 microbeads (2). The CD56-negative fraction (enriched for fibroblasts) was subsequently grown in skeletal muscle growth medium (PromoCell) and transduced with a GFP lentivirus at different doses (1:15, 1:30, 1:40 and 1:100). The transduction efficiency was measured by flow cytometry. For transdifferentiation, GFP-positive fibroblasts were exposed to 300 $\mu$M oleic acid and 300 $\mu$M palmitic acid complexed to BSA at 15 mg/ml in proliferation medium (1).
The transduction efficiency was measured by flow cytometry 24 hours post-transduction for each GFP-lentiviral dose. The transduction efficiency for each dose was 72% (1:15), 60% (1:30), 50% (1:40) and 30% (1:100). The 1:15 dose appeared to compromise fibroblast viability, so the 1:30 dose was selected for further transductions. Using this dose, the transduction efficiency was 75% five days after transduction. Following treatment with fatty acids for 72 hours, cells were fixed and analysed by immunohistochemistry using antibodies against the adipogenic transcription factors C/EBP\(\alpha\) and PPAR\(\gamma\), and Oil Red O which stains lipids. The results showed that applying fatty acids to GFP-positive fibroblasts resulted in their transdifferentiation into adipocytes as evidenced by a clear accumulation of Oil Red O positive lipid droplets and increased expression of the adipogenic transcription factors C/EBP\(\alpha\) and PPAR\(\gamma\) compared to the non-fatty acid treated GFP-positive fibroblasts.

This study confirms that GFP lentivirus transduction of human primary skeletal muscle derived fibroblasts does not affect their transdifferentiation potential and can therefore be used to successfully label cells for future in vivo experiments.


This work was funded by the BBSRC.

*Where applicable, the authors confirm that the experiments described here conform with the Physiological Society ethical requirements.*

---

**PC24**

**Acute effects of respiratory warm-up on exercise-induced bronchoconstriction and exercise performance**

P.A. Eichenberger\(^1\), T.A. Scherer\(^2\) and C.M. Spengler\(^1,3\)

\(^1\)Exercise Physiology Lab, Institute of Human Movement Sciences and Sport, ETH Zurich, Zurich, Switzerland, \(^2\)LungenZentrum Hirslanden, Zurich, Switzerland and \(^3\)Center for Integrative Human Physiology (ZIHP), University of Zurich, Zurich, Switzerland

Short bouts of whole-body warm-up exercise were shown to protect airways by attenuating bronchoconstriction in response to subsequent intense exercise in people with exercise-induced bronchoconstriction (EIB). Whether isolated respiratory warm-up offers similar refractoriness and whether this refractoriness translates into improved exercise performance is unknown. Thus, the aim of this study was to investigate whether 1) respiratory warm-up by normocapnic hyperpnea with partial rebreathing attenuates EIB severity during subsequent exercise and, 2) whether the suggested attenuation leads to improved exercise performance.

Nine subjects (6 females, 3 males; age: 25±5 years; forced expiratory volume in 1s [FEV\(_1\)]: 104±15% predicted) with a history of mild EIB and a ≥10% decrease in FEV\(_1\) after a control 8-min exercise challenge (ECh) took part in this study. They
were tested in 4 different conditions: Exercise after 1) no warm-up (NWU) or after 10min of respiratory warm-up at either 50% (WU50) or 70% (WU70) of maximal voluntary ventilation, or at variable intensity (30s-80%, 45s-30%, etc; WU80/30). Each warm-up was followed by an 8-min cycling ECh with dry air, followed – after 30min - by constant-load cycling to exhaustion (CL) at similar intensity and air condition. Lung function was measured at baseline, 0, 5, 10 and 15min after NWU/WU, and 5, 10, 15, 20, 25 and 30min after the ECh. Values are means±SD and compared by repeated-measures ANOVA.

The maximal decrease in FEV₁ after WU did not differ between conditions and never reached ≥10%. The maximal decrease in FEV₁ after the ECh was -14.9±3.6% in NWU which was significantly attenuated after WU50 (-9.3±5.0%), WU70 (-7.2±5.0%), and WU80/30 (-8.6±7.5%), with no difference between warm-up conditions (p>0.05).

Workload and ventilation during ECh did not differ between conditions, suggesting that the ventilatory stimulus to the bronchial system was similar. In NWU, FEV₁ immediately before CL was still significantly reduced compared to baseline and WU-conditions (all p<0.05). This did, however, not translate into significant improvements in times to exhaustion and did not affect ventilation and gas exchange during CL (all p>0.05).

These data indicate that intense respiratory warm-up carried out before whole-body exercise can attenuate EIB severity and improve recovery, even in the absence of significant airway narrowing acutely after warm-up. The lack of improvements in exercise performance might be due to a stronger bronchoprotection induced by the ECh, masking improvements observed with prior respiratory warm-up.

Where applicable, the authors confirm that the experiments described here conform with the Physiological Society ethical requirements.

PC25

The effect of carbohydrate mouth rinsing on fencing performance and cognitive function following a fatigue inducing simulated bout of fencing

L. Bottoms¹, G. Rowlatt² and R. Buscombe²

¹University of Hertfordshire, College Lane, UK and ²University of East London, Stratford, UK

The ergogenic effect of carbohydrate (CHO) ingestion both pre and during endurance sport has been well documented (Shabort et al, 1999). Carter et al. (2004) were the first to have subsequently established a performance effect of CHO independent of blood glycogen levels signalling a potential key role of the central nervous system. To investigate this phenomenon they employed a protocol whereby participants rinsed a CHO solution in their mouth before spitting it out, referred to as carbohydrate mouth rinsing (CMR). CMR has subsequently been shown to improve high intensity exercise lasting between 30 and 60 minutes (Jeukendrup et al, 2013), however to date there exists no tests of CMR in relation to completion of an intermittent sports specific testing protocol. The present study sought to
investigate the impact of CMR on cognitive and sports specific performance after a period of fatigue induced fencing. Twelve participants who were all regularly competing in national level fencing competitions and training a minimum of once per week volunteered to participate in the study (31.2±14.3 years; 81.4±16.5 kgs). On two separate occasions in a randomised cross over design, the participants undertook a standardised 10 minute sport specific warm up. The participants completed a Stroop and lunge test (measuring number of lunges and hits on target) pre and post execution of a previously validated fatigue inducing fencing protocol. During the fatiguing protocol the participants mouth rinsed between simulated fights 25ml of either a tasteless 6.7% maltodextrin solution (MALT) or 25ml of water (PLAC). Heart rate and perceived exertion (RPE) were measured throughout the fatiguing exercise protocol and blood lactate and glucose were measured pre and post exercise. A series of two-way repeated ANOVA’s were conducted with the various cognitive and physiological outcomes serving as dependent measures. The results demonstrated no interaction between pre and post and trial for the number of lunges (P>0.05), however there was an interaction for lunge accuracy (P<0.05), with accuracy improving post fatiguing exercise in the MALT trial (Table 1). There was also a tendency for RPE to be lower during the MALT trial compared to the PLAC (P=0.08). In conclusion, this study provides evidence for a positive effect of CMR on accuracy in a sports specific task. The RPE data is in line with the hypothesised role that CMR plays in mediating central processing in the perception of exertion after fatiguing exercise. CMR may be a suitable alternative to ingestion of CHO pre and during competitive sports performance.

Table 1: Mean (±SD) lunge accuracy pre and post fatiguing exercise for both trials

<table>
<thead>
<tr>
<th></th>
<th>Pre Protocol (%)</th>
<th>Post Protocol (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PLA</td>
<td>82.1 ±8.8</td>
<td>78.8 ±6.4</td>
</tr>
<tr>
<td>MALT</td>
<td>81.2 ±8.3</td>
<td>87.6 ±9.4</td>
</tr>
</tbody>
</table>


*Where applicable, the authors confirm that the experiments described here conform with the Physiological Society ethical requirements.*

---

**PC26**

**Longitudinal changes in body composition of inter-county Gaelic athletic association hurlers measured by dual-energy x-ray absorptiometry**

R. Davies, W. McCormack, C. Toomey and P. Jakeman

*Physical Education and Sport Sciences, University of Limerick, Limerick, Ireland*

The development of the high performance athlete involves cyclical periods of training and competition. Accurate and precise measurement of body composition
forms a central role in the development of the athlete or team yet longitudinal change in body composition is rarely reported. In this study we report the longitudinal change in body composition of elite, inter-county hurlers within season and over four sequential seasons. Whole body and segmental body compositional analysis was measured by dual energy x-ray absorptiometry (DXA) on 66 senior, male, outfield, inter-county hurlers, mean age 23.7 [95% CI, 22.9 : 24.5] y in the off-season period in September (BASAL). Further measurements were obtained at approximately 3 month intervals pre-competition (PRE), within-competition (IN) and in the off-season (OFF) of the following year. In addition, 11 players were followed across four consecutive seasons. Data are reported as the mean [95% CI]. Repeated measures ANOVA was used to assess change over time. Statistical significance was detected at 0.05 $\alpha$-level. Estimates of effect size were calculated separately, $\eta^2$ pertains to change over time while $R^2$ is used to represent the effect between composite variables and constituents, i.e. $\Delta$ fat mass and $\Delta$ body mass.

No change for body mass was observed from BASAL to PRE (0.21 kg [-0.77 : 0.39], -0.2% [-0.8 : 0.4], $p = 1.000$, $\eta^2 = 0.007$). A moderate reduction in body mass occurred from PRE to IN (-0.78 kg [-1.21 : -0.35], -0.9% [-1.4 : -0.4], $p = 0.002$, $\eta^2 = 0.169$) but increased from IN to OFF (1.46 kg [0.98 : 1.94], 1.7% [1.2 : 2.3], $p < 0.001$, $\eta^2 = 0.369$). No change was observed between BASAL and OFF (0.47 kg [-0.09 : 1.04], 0.61% [-0.06 : 1.28], $p = 0.219$, $\eta^2 = 0.049$). A concurrent increase in lean mass (1.04 kg [0.64 : 1.43], equivalent to 1.6% [1.0 : 2.2], $p < 0.001$, $\eta^2 = 0.307$), and decrease in fat mass (-1.26 kg [-1.64 : -0.87] equivalent to -8.1% [-10.8 : -5.5], $p < 0.001$, $\eta^2 = 0.365$), was observed BASAL to PRE. This was followed by the restoration of fat mass in the period IN to OFF (1.73 kg [1.33 : 2.12] or 12.4% [9.5 : 15.7], $p < 0.001$, $\eta^2 = 0.54$), with the trunk acting as the primary region of change (1.07 kg [0.84 : 1.30], $R^2 = 0.93$). Longitutinally, over four years, an overall decrease in body mass was observed (-2.05 kg [-3.37 : -0.73], -2.4% [-3.9 : -0.8], $p = 0.006$, $\eta^2 = 0.546$). In contrast the accrual of lean mass during his period was 1.3 % [0.7 : 2.0] or 0.88 kg [0.44 : 1.32] per annum, with similar within-season fluctuations in fat mass.

In conclusion, cyclical change in body composition occur within and between-season that belie change in body mass. Whilst cycling of fat mass persisted over consecutive seasons, the linear increase in lean tissue mass was a robust observation considered optimal for enhanced physical performance.

Where applicable, the authors confirm that the experiments described here conform with the Physiological Society ethical requirements.
Astrocyte activation in response to disease alters cerebrovascular function: implication for metabolic changes and perfusion stress in ageing

S. Serres¹,², M. Sarmiento Soto², J. Larkin², C. Martin²,³, A. Khrapitchev², V. Economopoulos², G. Bonvento⁴, C. Escartin⁴ and N. Sibson²

¹School of Life Sciences, University of Nottingham, Nottingham, UK, ²CRUK/MRC Oxford Institute for Radiation Oncology, University of Oxford, Oxford, UK, ³Psychology, University of Sheffield, Sheffield, UK and ⁴MIRCen CEA Saclay, Fontenay-aux-roses, UK

Background: Neurovascular coupling, or functional hyperaemia, serves to match local cerebral blood flow (CBF) to regional neuronal energy use ensuring normal functioning of the brain¹. This is thought to be accomplished by astrocytes that form a physical bridge between neurons and blood vessels². However, in response to disease, astrocytes become activated and this may have significant consequences for cerebrovascular function. The aim of this study was to determine the effects of astrocyte activation on brain vasculature using in vivo magnetic resonance imaging (MRI), laser speckle contrast imaging (LSCI) and histology.

Methods: Male rats (N=16) were anesthetized with 2% isoflurane and injected intracortically with either (i) a lentivirus expressing ciliary neurotrophic factor (Lv-CNTF; N=7) known to switch astrocytic phenotype to an activated state, or (ii) a self-inactivated lentivirus expressing LacZ (Lv-LacZ; N=9). 6 weeks later, animals were anaesthetised with 2% isoflurane, tracheotomised and artificially ventilated. The left femoral artery was cannulated for monitoring mean arterial blood pressure (MABP), blood gases (PaCO₂ and PaO₂) and pH. Animals underwent MRI to measure basal CBF and LSCI to measure the CBF response, to both electrical stimulation of the whisker pad and hypercapnic (CO₂) challenge, under 1.2% isoflurane in 70%N₂/30%O₂, and maintained at ~37°C. Animals were transcardially perfusion-fixed under terminal anaesthesia and histology was performed post-mortem to detect molecular and cellular markers associated with astrocyte activation. All data are given as mean ± SEM and compared by paired t-test.

Results: CBF responses to whisker-pad (9.7 ±2.0 vs 19.6 ±3.3%; injected vs non-injected; p<0.05) and hypercapnic (44.7 ±7.3 vs 68.1 ±1.0%; injected vs non-injected; p<0.01) challenges were significantly reduced in the CNTF-Lv animals. Similarly basal CBF was significantly reduced (49.0 ±10.5 vs 59.9 ±10.0ml/100g/min; injected vs non-injected; p<0.05) and correlated closely with the area of astrocyte activation (p<0.05; r²=0.3). Histologically, astrocyte activation was associated with changes in the microvascular network. The use of hypoxic probe pimonidazole revealed hypoxia during astrocyte activation, and thus potential metabolic changes. No changes were observed in the LacZ-Lv animals.

Conclusion and future directions: These findings suggest that metabolic and vascular changes associated with astrocyte activation may suppress neurovascular coupling, and thus alters normal functioning of the brain. In Nottingham, we aim to use cutting-edge imaging methods (e.g. Dynamic Nuclear Polarisation ¹³C magnetic
resonance spectroscopy) to detect specific metabolic changes associated with astrocyte activation and chronic perfusion stress in ageing that could be modulated by nutrition and exercise.


Where applicable, the authors confirm that the experiments described here conform with the Physiological Society ethical requirements.

---

PC28

The effect of regularly performing a single supramaximal cycle sprint on maximal aerobic capacity in sedentary men and women

R.S. Metcalfe1 and N.B. Vollaard2

1School of Sport, Ulster University, Derry, UK and 2Department for Health, University of Bath, Bath, UK

Supramaximal sprint interval training (SIT) provides a potent stimulus for improving maximal aerobic capacity (VO₂max), which is a strong marker for both endurance performance and future cardiovascular health and premature mortality. Cycling based SIT typically involves six or more ‘all-out’ 30-s Wingate sprints per training session, yet we have recently demonstrated that similar improvements in VO₂max can be achieved with as few as two 20-s sprints (1). This suggests that the volume of sprint exercise has limited influence on subsequent adaptations in VO₂max. In this study, we aimed to examine whether a single 20-s ‘all-out’ cycle-sprint per training session can provide a sufficient stimulus for improving VO₂max. Thirty sedentary participants (10 men / 20 women; mean±SD age 24±6 y, BMI 22.6±4.0 kg/m², VO₂max 33.2±7.1 mL/kg/min) were randomised to a training group (n=16) or a no-intervention control group (n=14). Training involved three exercise sessions per week for four weeks, consisting of a single 20-s Wingate sprint (no warm-up or cool-down). VO₂max was determined prior to training and three days following the final training session. Mean VO₂max did not significantly change in the training group (2.15±0.62 vs. 2.22±0.64 L/min) or the control group (2.07±0.69 vs. 2.08±0.68 L/min; effect of time: P=0.17; group x time interaction effect: P=0.26). In conclusion, although we have previously demonstrated that regularly performing two repeated cycle-sprints provides a sufficient training stimulus for a robust increase in VO₂max, our present study suggests that this is not the case when training sessions are limited to a single 20-s sprint.


Where applicable, the authors confirm that the experiments described here conform with the Physiological Society ethical requirements.
The content of full-length and truncated isoforms of PGC-1α in trained human skeletal muscles after low and high intensity endurance exercise

E. Lysenko, D.V. Popov, T. Vepkhvadze and O. Vinogradova

SSC RF Institute of biomedical problems RAS, Moscow, Russian Federation

It is known that full-length PGC-1α (FL-PGC-1α) in contrast to N-truncated (NT-PGC-1α) protein has a short half-life. Taking into consideration that the content of PGC-1α could influence further adaptive changes in muscle the aim of our study was to investigate the effect of ubiquitin-proteasome system activation after high intensity endurance exercise on PGC-1α content.

Nine healthy endurance-trained (VO2max 61 ml/min/kg) subjects performed two continuous 70 min bicycle sessions on separate occasions: with low (L; 50% VO2max) and high (H; 70% VO2max) intensity. Before exercise, and 2 minutes, 4 and 8 hours after it biopsy samples from the m. vastus lateralis were taken under local anaesthesia (2 mL 2% lidocaine) by a microbiopsy technique. mRNA expression level, total and phosphorylated protein content were evaluated using q-PCR and Western blot. All data are normalized to reference gene or protein and submitted as median and interquartile range. The study was approved by the Human Ethics Committee of the Institute of Biomedical Problems (Moscow, Russia).

Immediately after exercise increase in phosphorylation level of AMPK substrate – ACCSer79 in both sessions was observed (from 0.09(0.05-0.18) to 0.24(0.11-0.72) in L-session; from 0.08(0.04-0.30) to 0.52(0.19-1.06) in H-session). PGC-1α mRNA expression level after 4 hours of recovery also increased in a load-dependent manner (from 0.15(0.10-0.20) to 0.37(0.29-0.45) in L session; from 0.14(0.10-0.16) to 0.67(0.45-0.84) in H session). Phosphorylation of FOXO1 Ser256 increased in L session immediately after the exercise (from 1.31(0.81-2.10) to 1.46(1.08-3.50)), and decreased after 4 hours recovery (from 1.88(0.73-2.31) to 0.87(0.26-2.43)) in H session. MuRF1 expression decreased only immediately after L session (from 0.22(0.13-0.30) to 0.14(0.11-0.17)), whereas Atrogin-1 expression decreased in both groups: in L session after 8 hours from 1.38(0.87-1.83) to 0.67(0.61-1.45); and in H session after 4 hours from 1.38(0.77-1.68) to 0.80(0.70-0.90) and after 8 hours to 0.83(0.71-1.26)). Content of FL-PGC-1α was unchanged in L session, and had a tendency to decrease in H session immediately after the exercise (from 1.00(0.60-2.00) to 0.60(0.45-1.45); P=0.06). Whereas the content of NT-PGC-1α increased in L session (from 0.76(0.38-1.57) to 1.08(0.72-1.74)) and had a tendency to increase in H session (from 1.06(0.42-1.34) to 1.45(0.40-3.68), P=0.06).

Thus the high intensity endurance exercise in comparison with the low intensity exercise results in ubiquitin-proteasome system activation. As the stability of FL-PGC-1α is low, this result may indicate that its content decreases after high intensity endurance exercise.
This work was supported by the Russian Science Foundation (grant 14-15-00768).

Where applicable, the authors confirm that the experiments described here conform with the Physiological Society ethical requirements.

PC30

Chronic probiotic supplementation and its effects on ehsp72 concentration following a desert-based ultramarathon

L. Taylor¹, C. Suckling², J. Roberts², B. Chrismas³ and H. Marshall⁴

¹Athlete Health and Performance Research Centre, Aspetar Orthopaedic and Sports Medicine Hospital, Doha, Qatar, ²Department of Life Sciences, Anglia Ruskin University, Cambridge, UK, ³College of Arts and Sciences, Qatar University, Doha, Qatar and ⁴Sport Science and Physical Activity Research, University of Bedfordshire, Bedford, UK

Extracellular heat shock protein 72 (eHsp72) concentration has been shown to increase in response to exercise and/or environmental stress within humans. Ultra-endurance athletic events expose participants, including elite athletes, to a prolonged duration of exercise, often in challenging environmental conditions including extreme heat [e.g. Marathon des Sables (MDS)]. Such conditions increase risk of exertional heat illness and related pathophysiology’s, including cellular damage. Probiotic and glutamine supplementation have been shown to increase eHsp72 concentration, which may subsequently lead to a reduction in cellular damage and offer a role of cellular protection, particularly to the gut, and may ultimately improve performance and gut health, in events like the MDS. The eHsp72 response to probiotic supplementation and ultra-endurance events in MDS like events has received little attention and thus research is required to understand how the heat shock response can aid cellular protection (and perhaps performance) during such events. The present study explored chronic probiotic supplementation on the eHsp72 response to the MDS. Thirty-two (6 female) competitors (age 41 yrs; range 23-53 yrs, height 1.75 ± 0.08 m, body mass 77.05 ± 12.00 kg) were randomly allocated to receive probiotic (PRO), probiotic and glutamine (PGLn), or no (CON) supplementation for 12 wk prior to the MDS. Blood samples via venepuncture were collected: i) 12 wk (baseline), ii) 7 d (pre-race) prior to departure for the MDS; iii) post-race (within 6-8 h of race completion) and iv) 7 d post-race. The MDS 2015 consisted of 7 d of consecutive stages across the Sahara Desert, Morocco, with a total distance of 249.4 km (average temperature ~ 38°C). Plasma eHsp72 concentration was determined via ELISA and expressed as percentage change from baseline. Mean post-race eHsp72 concentration was significantly increased (p < 0.05) by 124% from baseline, however there was no significant effect of group on eHsp72 concentration at any time (p > 0.05). PRO and PGLn did not alter the eHsp72 response to the MDS. However, this result could be attributed, in part, to experimental limitations. Firstly, post-race data collection was delayed (samples obtained 6-8 h post-race completion) due to the unique logistical challenges associated with the MDS and thus a true zenith in eHsp72 concentration within and between
**Poster Communications**

Does dancing in old age afford neuromuscular protection?

M.V. Narici¹, K. Rehfeld², N. Müller³, D. Rankin¹ and A. Hökelmann²

¹MRC-ARUK Centre for Musculoskeletal Ageing Research, Faculty of Medicine, University of Nottingham, Derby, UK, ²Institut für Sportwissenschaft, Otto- von- Guericke-Universität Magdeburg, Magdeburg, Germany and ³Helmholtz Associat, German Centre for Neurodegenerative Diseases (DZNE), Magdeburg, Germany

Motor neuron degeneration, denervation, loss of structural and functional integrity of the neuromuscular junction (NMJ) and loss of motor units (MUs), markedly contribute to the age-related decline in muscle mass (sarcopenia) (Deschenes, 2011). Evidence of NMJ degeneration in sarcopenic individuals is now available from serum measurements of c-terminal peptide agrin fragment (CAF), a breakdown product of the heparan sulphate proteoglycan agrin, released after NMJ damage (Hettwer et al. 2013). Interestingly, aerobic exercise in senile rats seems to protect against denervation and NMJ degeneration (Valdez et al. 2010) and in humans, no decline in MUs has been found in muscles of master runners (Power et al. 2010). Hence the present study aimed to investigate whether an aerobic activity such as dancing could have neuroprotective effects when compared to conventional gym exercise training. Thirty-seven older individuals (aged 71.6±3.5 yr) were recruited (18 female and 19 male) and randomly assigned either to a Dance Group (DG, 9 female, 10 male) or to a Gym Exercise Group (GEG, 9 female, 9 male). Both interventions took place twice a week, lasted 90 minutes each, for a period of six months. DG training consisted of Line, Jazz, Rock ‘n’ Roll, Latin-American and Square dances. GEG training consisted of endurance, strength-endurance and flexibility training. For both DG and GEG, each set of exercises/dances, lasted 20 minutes. Blood samples were collected before and after the intervention to measure CAF levels in serum using a commercially available Elisa kit (NTCAF ELISA, Neurotune AG, Schlieren, Switzerland). The data were compared to those of reference populations of older sarcopenic and young controls (Hettwer et al. 2013). Values are means ± S.D., compared by paired or unpaired Student’s t-Test, as appropriate. Since no significant differences were found between CAF values of male and female participants of both groups, values were pooled together. Pre-training, CAF values of the DG groups may not have been obtained. Secondly, again due to logistical challenges, pre and post discrete stage blood samples were not obtained; consequently within and between stage nadir and zeniths of eHsp72 concentrations, and the influence of PRO and PGLn upon this, were not provided by the present data. Nevertheless, PRO and PGLn supplementation did not enhance, or acquiesce, the eHsp72 response to the MDS relative to the experimental limitations provided.

Where applicable, the authors confirm that the experiments described here conform with the Physiological Society ethical requirements.
(202.9±66.3 pM) and GEG (228.5±70.5 pM) groups were respectively 1.9 and 2.2-fold higher than those of the young reference population and were statistically not different from the aged-matched elderly controls (214.1±118.2 pM). However, after the 6-month intervention period, CAF levels decreased by 15% (P<0.001) in DG, (pre 202.6±66 pM post 172.1±50.2 pM) while no changes were found in the GEG (pre 228.5±70.5pM, post 219.7±60.0 pM, n.s.). The present findings suggest a reduction of neuromuscular degeneration in older humans as a result of a six-month recreational dancing intervention. Instead, general fitness training based on strength, endurance and flexibility exercises does not seem to produce these benefits. It is not clear how dancing affords this protection but this could be due to a reduction of oxidative stress, inflammation and/or improved neurotrophin levels (Gonzalez-Freire et al. 2014).


*Where applicable, the authors confirm that the experiments described here conform with the Physiological Society ethical requirements.*

---

**PC32**

**Effect of a short duration high intensity/low volume resistance training on skeletal mRNA in young healthy subjects**

A. Paoli¹, T. Moro¹, L. Monaco², F. Naro² and C. Reggiani¹

¹Department of Biomedical Sciences, University of Padova, Padova, Italy and ²DAHFMO Unit of Histology and Medical Embryology, Sapienza University, Roma, Italy

**Introduction**

Resistance training may be carried out via different methods that have been shown to have differing effects on muscle metabolism and signalling pathways. As a matter of fact a resistance training program is a composite of several important variables including that may affect physiological outcomes. On the other way also an high intensity interval exercise performed on cycloergometer has been demonstrated to influence some metabolic pathway as PGC-1α. Thus, the aim of our study was to analyse mRNA response to a single bout of high-intensity resistance training (HIRT), traditional resistance training (TRT) and high-intensity interval training (HIT).

**Methods**
12 healthy subjects performed in two different moments and with different legs HIRT and TRT protocol. HIRT consisted in 2 sets of 6/2/2 reps with incomplete rest between (20") sets while TRT consisted of 4 sets x15 reps with 1'15" of rest between sets. HIT was performed on a cycloergometer as follow: 30" of all out with 4’ of rest, repeated for 4 times. Biopsies from the vastus lateralis were taken one week before training sessions (pre), immediately after (T0), 6 hours after (T6) and 24 hours after (T24) training. The following genes, related to hypertrophy, metabolism, autophagy and inflammation, was analysed by RT-qPCR: IGF-1, IGF-14a, MGF, myostatin, STARS, PGC-1α, PGC-1α-4, Atrogin, Beclin, IL6, myogenin

Results
Our data showed that HIRT seems to influence in a greater extent the gene linked to mechanical deformation (MGF) and STARS, whilst TRT seems influence STARS and IGF-1. HIT influenced IGF-14a, Beclin, IL6, myogenin, PGC-1α and myostatin.

Discussion
Our results suggest that different kind of exercise may influence different early genes after exercise. An high resistance training (HIRT) affects mechanical-related factors whilst a more traditional, long duration resistance training (TRT) seems to influence the IGF-1 pathway. The HIT exercise increases in a significant manner PGC-1α but also muscle atrophy related genes as atrogin, beclin and myostatin.


Where applicable, the authors confirm that the experiments described here conform with the Physiological Society ethical requirements.

PC33

Identifying exercise-sensitive sirtuin 1 networks in skeletal muscle

B. Stocks1, S. LaBarge2, J. Dent1, L. Hamilton3, S. Schenk2 and A. Philp1

1School of Sport, Exercise and Rehabilitation Sciences, University of Birmingham, Birmingham, UK, 2University of California, San Diego, San Diego, CA, USA and 3University of Stirling, Stirling, UK

Endurance performance relies upon efficient production of ATP in skeletal muscle via mitochondrial oxidative phosphorylation. As such, skeletal muscle mitochondrial biogenesis is a predominant mechanism by which endurance training improves performance. From a molecular perspective, various molecules interact to regulate mitochondrial content and function in skeletal muscle. Sirtuin 1 (SIRT1), a NAD+-dependent deacetylase, has been proposed to play an intimate role in mitochondrial biogenesis and is sensitive to metabolic fluctuations
invoked by endurance exercise. However, despite considerable research attention, relatively little is known regarding exercise-induced adaption mediated by SIRT1 in skeletal muscle. Therefore, to determine SIRT1-deactylase dependent signalling in skeletal muscle, SIRT1 muscle-specific knockout mice (mKO) and control wild-type (WT) littermates underwent acute treadmill running in the fasted state (60 minutes at intervals of 5-25 m/min @ 10° gradient). Following endurance performance, mice were sacrificed immediately post exercise and one and three hours-post exercise (n=6/group). Immunoblotting techniques were used to determine protein content and post-translational modification of the purported SIRT1 targets p53, CREB and AMPK. Despite loss of SIRT1 activity in the mKO group, we observed comparable phosphorylation of p53, CREB and AMPK post exercise in both mKO and WT mice, suggesting that factors in addition to SIRT1 regulate the phosphorylation and presumed activity of these targets following endurance exercise.

Where applicable, the authors confirm that the experiments described here conform with the Physiological Society ethical requirements.

PC34

Biomechanics and the cardiorespiratory responses to self-selected running speed in simulated altered gravities – a case study

P. Carvil¹, T. Russomano¹,², R. Baptista², V. Jain¹, K. Lindsay¹, T. Subasinghe¹, J. Waldie³ and D.A. Green¹

¹Centre for Human and Aerospace Physiological Sciences, King’s College London, London, UK, ²Microgravity Centre, School of Engineering, PUCRS University, Porto Alegre, Brazil and ³RMIT University, Melbourne, VIC, Australia

Introduction: The human body has evolved in Earth’s gravity (1Gz), effecting physiological development and daily locomotion. When exposed to extended periods of microgravity, physiological de-conditioning ensues, despite exercise being implemented to counter deconditioning. With further exploratory missions planned away from Earth’s 1Gz environment, more comprehensive countermeasures are required to protect the human body. The SkinSuit provides a potential integrative countermeasure against microgravity deconditioning by imparting a cumulative axial loading regime, however little research exists on the effects of reloading subjects in altered gravities. A range of ‘gravity loading’ was created to study the response to running, at self-selected speed.

Methods: A healthy male (72kg; 1.70m; 26yr) volunteered for the study which received local ethical approval by PUCRS Research Ethics Committee. After familiarisation and a five minute resting state, the subject performed five minutes of running at a self-selected running pace on a treadmill at three randomised gravities, once with and once without the SkinSuit. In addition to normal 1Gz
running, bodyweight suspension was used to unload the subject to simulate Martian (0.38Gz) and Lunar (0.16Gz) gravities; when worn the SkinSuit provided approximately an additional 0.8Gz of axial loading, thus creating a range of ‘gravity loading’ (0.16-1.8Gz). Respiratory responses, heart rate (HR), gait kinematics and ratings of subjective comfort (1-10), were reported for rest and the final minute of each run.

**Results:** Respiratory responses were positively, linearly associated with gravity loading (r=0.94), with minute ventilation increasing from rest by 10.9 l.min⁻¹ when running at normal 1Gz without the SkinSuit, to 31.3 l.min⁻¹ when running at 1Gz with the addition of the Skinsuit (+0.8Gz). HR was not associated with loading, but was associated with self-selected running speed. In reduced simulated gravities i.e. Lunar, a change of gait was observed with a shift to ‘progressive jumping’. Greater need for movement control (4/10 vs.1/10) was reported when wearing the SkinSuit.

**Conclusions:** In this case study a linear, positive, trend between ‘gravity loading’ and respiratory response was observed. When the SkinSuit (0.8Gz) was combined with the Lunar simulation (0.16Gz), approximating Earth’s 1Gz, the respiratory responses were nearly identical, indicating the potential role of gravity loading on metabolic cost.

The authors would like to thank the European Space Agencies’ Space Medicine Office for the loan of the skinsuit.

*Where applicable, the authors confirm that the experiments described here conform with the Physiological Society ethical requirements.*

---

**PC35**

**Extended field of view ultrasound compared to MRI in the assessment of changes in skeletal muscle cross-sectional area and volume**

M.V. Franchi¹, J.I. Quinlan¹, L. Philbrooks¹, A. Hale², B.E. Phillips¹, P.L. Greenhaff³, N.J. Szewczyk¹, P.J. Atherton¹, S. Francis², K. Smith¹ and M.V. Narici¹

¹MRC-ARUK Centre of Excellence for Musculoskeletal Ageing Research, Division of Medical Sciences & Graduate Entry Medicine, School of Medicine, University of Nottingham, Derby, UK, ²MRC-ARUK Centre of Excellence for Musculoskeletal Ageing Research, Sir Peter Mansfield Imaging Centre, University of Nottingham, Nottingham, University of Nottingham, NOTTINGHAM, UK and ³MRC-ARUK Centre of Excellence for Musculoskeletal Ageing Research, School of Life Sciences, University of Nottingham, QMC, University of Nottingham, NOTTINGHAM, UK

The assessment of changes in skeletal muscle mass is an important requirement, as several medical conditions involve severe muscle loss (cachexia, sarcopenia) (Heymsfield *et al.* 2014). Furthermore, accurate measurement of anatomical cross sectional area (ACSA) and muscle volume enable the estimation of
hypertrophy produced by different regimes of overloading (Narici et al. 1996, 2003). Computer Tomography (CT), Dual-Energy X-Ray absorptiometry (DXA) and Magnetic Resonance Imaging (MRI) are gold-standard techniques used in clinical settings for the evaluation of muscle mass: yet these techniques are expensive and often not easily accessible. Recently, the use of extended field of view (EFOV) ultrasound has been advocated as a reliable alternative for assessing vastus lateralis and quadriceps ACSA (Ahtiainen et al. 2010, Noorkoiv et al. 2010). However, the validity of the EFOV technique as compared to MRI in the assessment of regional and total muscle hypertrophy in response to chronic overloading regimes has not yet been investigated. The present study aims to determine whether EFOV is an accurate and reliable method for measuring quadriceps femoris (QF) and vastus lateralis (VL) muscle ACSA and total volume, as well as its ability to detect changes thereof during long term overloading regimes. Muscle mass of nine recreationally active males (8 young, 25 ± 6 years old and 1 elderly, 65 years old), taking part in an 8-wk resistance training study, was assessed by EFOV US and MRI at 0, 4 and 8 week time points. ACSA was measured at 10, 20, 30, 40, 50 and 60% of femur length (FL) (from the medial patella border to the greater trochanter process) by EFOV US and compared with MRI. Pearson correlation and linear regression between the two techniques showed strong correlation between ACSA at mid regions (40, 50, 60%) of the QF 50 and 60% FL (R² = 0.95 and 0.90, respectively) and the VL (50% and 60% LF (R² = 0.91 and 0.89 respectively). Additionally, the two techniques showed good agreement when the average difference (D) in ACSA was assessed at these specific locations for quadriceps (D = 5.7 and 5.6% respectively) and for VL (D = 18.2 and 17.9 respectively). Furthermore, QF volume and VL volume (up to 60% of FL) showed a strong correlation (R² = 0.85 and 0.89 respectively), as did measurements for whole QF volume (R² = 0.92) (D= 9.3, 20.7 and 11.4% respectively). Despite a systematic underestimation by US, a strong correlation existed between EFOV US and MRI for the values of ACSA and of VOL measured at the three time points (0, 4 and 8 wks). Thus, these results show that EFOV US is a valid and reliable technique to quantify muscle ACSA and volume, and represents a useful tool for the assessment of regional and total changes in skeletal muscle mass.

Heymsfield et al. (2014), J Cachexia Sarcopenia Muscle 5:9–18
Narici et al. (1996), J Physiol 496 (Pt 1):287-97
Narici et al. (2003), Journal of Applied Physiology 95, 2229–2234
Noorkoiv et al. (2010), European Journal of Applied Physiology 109, 631–639

Biotechnology and Biological Science Research Council (BBSRC) U.K.

Where applicable, the authors confirm that the experiments described here conform with the Physiological Society ethical requirements.
Do changes in neuromuscular activation contribute to the quadriceps femoris angle-torque relationship?

M.B. Lanza, T.G. Balshaw and J.P. Folland

School of Sport, Exercise and Health Sciences, Loughborough University, Loughborough, UK

Introduction: Joint position and muscle length are well known to influence torque production and the angle-torque relationship has been described for many muscle groups including Quadriceps Femoris (Q). However, contrasting reports exist as to whether neuromuscular activation changes with joint position and contributes to the Q angle-torque relationship (Kubo et al. 2004; Kooistra et al. 2007). Therefore, the aim of this study was to investigate Q neuromuscular activation, using surface electromyography (EMG) and the interpolated twitch technique (ITT) at four knee joint angles (25°, 50°, 80° and 105°; 0° = full knee extension).

Method: Thirteen healthy males (21 ± 2 years; 1.78 ± 0.07 m; 73 ± 5 kg) completed two familiarization and two identical experimental sessions. Test sessions involved isometric torque and EMG (6 sites, 2 electrodes on each of the superficial quadriceps; Delsys Trigno, Boston, MA) recordings of the right leg (Q) at each knee joint angle (25°, 50°, 80° and 105°; 0° = full knee extension). Measurements included maximum voluntary torque, maximal M-wave peak-to-peak amplitude (Mmax P-P), absolute EMG root-mean-square amplitude at MVT (EMGMVT), EMGMVT normalised to Mmax P-P (EMGMVT-PP). Doublet stimulation at rest and superimposed during sub-maximal and maximal contractions was used to calculate neuromuscular activation (ACT) at MVT.

Results: Maximal voluntary torque (MVT) was significantly influenced by joint angle with MVT greater (Bonferroni, P ≤ 0.001) for the mid-range positions (50°, 256 ± 34 Nm; 80°, 273 ± 37 Nm) than the most extended (25°, 136 ± 33 Nm) and flexed (106° 218 ± 36 Nm) positions. ACT was lower at the most extended positions (25° 83 ± 9%; 50° 83 ± 7%) compared to the most flexed positions (106° 94 ± 3%; 80° 95 ± 3%; Bonferroni, P≤0.029). Absolute EMG at MVT (EMGMVT) showed no significant difference between angle positions (ANOVA, P=0.246), although EMGMVT-PP showed a tendency to be lower at 25° (7.03 ± 1.80%) than 80° (8.24 ± 2.18%; Bonferroni, P=0.087).

Conclusion: ACT, calculated with the ITT, showed differences between angle positions that appears to contribute to the angle-torque relationship. In contrast, the similarity in absolute and normalized EMGMVT across the measured knee joint
angles suggested similar neural drive across the measured joint angles. Based on these contrary findings it remains ambiguous if Q neuromuscular activation changes with knee joint angle.

Kooistra, RD et al. (2007). EJAP 309P

Where applicable, the authors confirm that the experiments described here conform with the Physiological Society ethical requirements.

The effect of gravity-loading - via the Mk VI Gravity-Loading Countermeasure Skinsuit - upon maximal aerobic exercise (VO_{2max})

J. Attias1, J. Scott2, T. Russomano1 and D.A. Green1

1Centre of Human and Aerospace Physiological Sciences, King’s College London, London, UK and 2Space Medicine Office, Cologne, Germany

Introduction: Physiological de-conditioning associated with spaceflight and disuse environments is a major concern. The Gravity-Loading Countermeasure Skinsuit (GLCS) attempts to recreate gravity via incremental increases in z-axis fibre tension along the body’s longitudinal axis, in a manner analogous to Earth’s gravity. Conceptually, the Mk VI can be utilised by a spaceflight crew during exercise countermeasures and sleep. In order to evaluate whether the GLCS has scope as a countermeasure garment, it was necessary to determine its effect upon the cardiorespiratory responses to maximal aerobic exercise.

Methods: In two separate randomised visits, eight male subjects (29.6±5.6 yrs; 177.1±6.8 cm and 74.2±7.1 kg) completed a cycle ergometer maximal oxygen uptake (VO_{2max}) test (Bruce protocol) with stepwise increments of 50W every 3 minutes, whilst wearing either a custom-fabricated Mk VI GLCS or loose fitting clothing (GYM). Cardiorespiratory parameters (breath-by-breath; H_{R}, V_{tex}, FR, TI/TTOT, V_E, RER and VCO_{2}), and subjective comfort, body control and rating of perceived exertion (RPE) were measured continuously and analysed at rest, 75% VO_{2max} and at VO_{2max}. Student’s t-test for paired data and Wilcoxon test was used to analyse physiological (± SEM) and subjective data (±95% confidence intervals).

Results: V_{Tex} was decreased (p=0.021) in GLCS vs. GYM at 75% VO_{2max}, though no other cardiorespiratory parameter was different between attires at rest, 75% VO_{2max} or VO_{2max}. Absolute VO_{2max} and the wattage required to achieve it were not different between GYM and GLCS (55.35ml/kg/min^{-1} vs. 54.09ml/kg/min^{-1} & 275W vs. 268.75W respectively). Furthermore, there was no difference in anaerobic threshold – determined by the elicited VO_{2} at the point of anaerobic threshold detection – between GYM and GLCS. However, total work product (KiloWatts [KW]) was 12.6% lower in the GLCS (148.1 KW ± 16.9 vs. 132KW ± 15.8 in GYM; p=0.001). Movement discomfort (p=0.02) and body control (p=0.02) - both with
scales of 0-10 where 0 is least discomfort and most control - were increased in the GLCS at rest albeit remaining moderate, but were no different at VO2max, whereas RPE and thermal comfort were unaffected throughout.

Discussion: The MK VI GLCS did not significantly affect VO2max, maximal wattage or cardiorespiratory responses at VO2max, but did reduce the total work performed. These data suggest that the GLCS does not inhibit oxygen uptake during maximal exercise, but may reduce the duration of work required to achieve a given physiological output. This may have application to as a countermeasure for astronauts and as a rehabilitation tool for a number of populations.

EPSRC (UK)
Space Medicine Office (Germany)

Where applicable, the authors confirm that the experiments described here conform with the Physiological Society ethical requirements.

PC38

Do muscle-tendon unit and patellar tendon stiffness influence explosive strength in man?

G. Massey1,2, T.G. Balshaw1,2, T. Maden-Wilkinson1, N. Tillin3 and J.P. Folland1,2

1Loughborough University, Loughborough, UK, 2Arthritis Research UK, Centre for Sport, Exercise and Osteoarthritis, Loughborough, UK and 3University of Roehampton, Roehampton, UK

Introduction: Stiffer connective tissues (muscle-aponeurosis and tendon) theoretically facilitate the rate of force transmission from the contractile apparatus to the skeleton and thus the capability of the muscle-tendon unit (MTU) to rapidly develop torque (i.e. explosive strength, ES). However, an association between in vivo tissue stiffness (k) and ES remains unsubstantiated. Recent work suggests MTU k may not discriminate inter-individual differences in ES (1). Whether tendon k separately influences ES is unexplored. Purpose: To examine the relationship between absolute and relative tissue k (both MTU and tendon) and ES.

Methods: Following familiarisation, 52 healthy untrained males (18-30 yrs) completed duplicate test sessions. Isometric knee extension contractions were performed (~110° knee angle) with a strain gauge perpendicular to the tibia sampling external force. Maximal voluntary torque (MVT) was assessed before a series of explosive voluntary and involuntary (supra-maximal octets [8 pulses at 300Hz] electrically evoked via femoral nerve stimulation) contractions. Measures of ES were time to absolute and relative torque levels (50 Nm & 25% MVT increments), and sequential time periods (e.g. t25-50% MVT). Constant loading-rate ramp contractions were performed with simultaneous force and ultrasound recordings of both vastus lateralis aponeurosis and patellar tendon (PT) elongation to derive MTU
and PT k. Absolute (N/mm) and relative (to MVT and resting tissue length) k were measured over identical torque ranges as the ES measures. Pearson correlations tested relationships between tissue k and ES.

Results: Absolute MTU and PT k were unrelated to absolute voluntary or involuntary ES measures (-0.243>r< -0.002, 0.092<P<-0.99). Relative PT k was also unrelated to any voluntary or involuntary ES measure (-0.246>r< -0.004, 0.085<P<–0.976). In contrast, relative MTU k was related to some measures of relative voluntary ES: t25-50% (r=-0.411, P=0.003), t50-75% (r=-0.314, P=0.028) and t75% (r=-0.298, P=0.038). Relative MTU k was related to involuntary t25-50% (r=-0.389, P=0.006) with a tendency to relate to involuntary t50% (r=-0.273, P=0.06).

Conclusions: Absolute and relative PT k were not associated with ES, and this was also the case for absolute MTU k. Relative MTU k was however associated with relative measures of voluntary and involuntary ES. These results suggest a differential influence of tissue components (muscle-aponeurosis vs tendon) on relative ES. However the overriding influence of maximum strength and/or tissue length seemingly negate any relationship between absolute MTU k and ES.


Where applicable, the authors confirm that the experiments described here conform with the Physiological Society ethical requirements.
voluntary fatigue (visit 2). This was followed 24h later by a simulated 30 minute cycling TT (visit 3). Blood samples were obtained in all visits; before, during, and after exercise; to identify changes in oxidative stress markers. A repeated measures ANOVA was used to determine significant differences between conditions, all values are means ± standard error. Markers of oxidative stress malondialdehyde (MDA), protein carbonyls (PC), or total antioxidant capacity (ferric reducing ability of plasma (FRAP)) were not different between the CA and PLA groups. FRAP increased in response to exercise during both trials (Pre visit 2: 508µM ± 18 to Post visit 2: 613µM ± 21, p < .05; Pre visit 3: 552µM ± 14 to Post visit 3: 603µM ± 22, p > .05). MDA showed a small increase over the two trials (Pre visit 2: 10.4µM ± .56 to Fatigue at 95%W_\text{max} 11.4µM ± .47, p > .05; Pre visit 3: 9.9µM ± .52 to Post visit 3: 11.7µM ± .86, p > .05) and there was a tendency for PC to decrease during the TT (Pre visit 3: 1.3 nm/mg ± .14 to Post visit 3: 1.1nm/mg ± .12, p > .05). TT finishing time was not different between CA and PLA (CA: 1605 secs ± 111; PLA: 1609 secs ± 115) nor was power output (CA: 292W ± 34.8; PLA: 292W ± 40.1). These findings indicate 8 days of CA supplementation did not attenuate oxidative stress, nor augment antioxidant defences in trained cyclists compared to PLA. Furthermore, CA did not enhance recovery 24 hours after completing a strenuous cycling protocol or provide an ergogenic effect in a cycling TT performance.

Where applicable, the authors confirm that the experiments described here conform with the Physiological Society ethical requirements.

---

**PC40**

**Examining the role of mTOR localisation in human skeletal muscle responses to protein and carbohydrate ingestion.**

J. Dent\(^1\), Z. Song\(^1\), M. McLeod\(^1\), L. Breen\(^1\), L. Hamilton\(^2\) and A. Philp\(^1\)

\(^1\)School of Sport, Exercise and Rehabilitation Sciences, University of Birmingham, Birmingham, UK and \(^2\)University of Stirling, Stirling, UK

The mechanistic target of rapamycin (mTOR) is a key regulator of protein synthesis in skeletal muscle particularly sensitive to nutrient availability. It is not fully understood how carbohydrate and amino acid availability results in activation of mTOR or the downstream propagation of intracellular signals resulting in cell growth in human skeletal muscle. Recently, it has emerged that mTOR localisation to the surface of the lysosome, and translocation to the cell membrane in its active form may be critical for its nutrient-stimulated downstream effects. We utilized novel biochemical approaches to study mTOR localization and protein complex formation in human skeletal muscle in the fasted state and 1h and 3h post consumption of a protein-carbohydrate beverage (Gatorade Recover®, Gatorade, IL, USA) providing 20/44/1g of protein/carbohydrate/fat. In contrast to cell and rodent studies, we observed mTOR to interact with the lysosomal marker LAMP2 in basal conditions.
and mTOR/LAMP2 complexes translocating to the cell periphery following nutrient stimulation. This redistribution of mTOR coincided with increased mTOR activity as assessed via kinase activity and immunoblotting of proximal targets of mTOR. Collectively our results provide information about the nutrient-sensing mechanisms regulating the activation of mTOR in skeletal muscle, suggesting that mTOR cellular localisation may be fundamentally important for the initiation of the protein synthetic response following nutrient stimulation in human skeletal muscle. It is anticipated that further understanding of these mechanisms will optimize our ability to combine the two potent activators of skeletal muscle protein synthesis - resistance exercise and nutrition - to maximize the growth response in humans.

Where applicable, the authors confirm that the experiments described here conform with the Physiological Society ethical requirements.

---

**PC41**

Effects of regular aerobic training on peripheral vascular activity in young healthy males

N. Potocnik, K. cankar, Z. melik and M. strucl

Medical Faclty, Insitute of Physiology, Ljubljana, Slovenia

Physical activity is known to have beneficial effects on prevention of cardiovascular disease. The regular aerobic exercise is associated with higher central arterial compliance, but its effect on peripheral arterial compliance is controversial. We aimed to test the hypotheses that regular aerobic training provokes beneficial changes in peripheral vascular activity at rest. Further we aimed to determine the influence of different autonomic stimuli (0.1Hz breathing and mental arithmetic stress) on peripheral vascular reactivity in physically trained young healthy adults compared to their sedentary peers.

Experiments were performed on 21 males, 19-24 years old (12 physically trained, $\text{VO}_2\text{max} = 40\pm3 \text{ ml/kg/min}$ - group A, 11 sedentary controls, $\text{VO}_2\text{max} = 33\pm4 \text{ ml/kg/min}$ - group B). Written informed consent was obtained from each and the study was conducted in accordance with the Helsinki Declaration. $\text{VO}_2\text{max}$ was determined directly on a separate day using cycloergometry (Quark CPET, Cosmed). On the testing day ECG, arterial blood pressure (Finapres, Ohmeda) and peripheral artery compliance on the finger artery at rest, 3 minutes during 0.1Hz breathing and 3 min during mental arithmetic challenge were measured. A noninvasive method based on the comparison of the arterial pressure and arterial volume of finger artery was used to measure peripheral artery compliance evaluated as compliance index (CI).

Our results revealed elevated CI in group A compared to group B ($3.42\pm0.30$ and $1.28\pm0.31$, $p=0.004$) at rest, but no significant differences in CI between groups during both physiological stimuli. CI decreased during 0.1Hz breathing ($1.53\pm0.20$, $p=0.003$) and mental stress ($0.87\pm0.13$, $p=0.002$) in group A, but only during
mental stress in group B (0.59 ±0.12, p=0.03). There were no differences in heart rate (p=0.08 at rest, 0.12 at 0.1Hz breathing and 0.34 at stress test), systolic and diastolic blood pressure between groups, at rest or during autonomic stimuli. A linear correlation between CI and VO\textsubscript{2max} was found (p<0.001) at rest, during 0.1Hz breathing (p=0.017) and in mental stress (p=0.007). Regular aerobic training increases peripheral arterial compliance in healthy subjects. Surprisingly the increase was not found during 0.1Hz breathing and mental arithmetic. Our findings indicate that peripheral and not central autonomic mechanisms govern peripheral arterial properties in young healthy males.


Where applicable, the authors confirm that the experiments described here conform with the Physiological Society ethical requirements.

---

AMPK does not play a requisite role in regulation of PGC-1\textalpha gene expression via alternative promotor in endurance-trained human skeletal muscle

D.V. Popov\textsuperscript{1,2}, E. Lysenko\textsuperscript{1,2}, A.D. Butkov\textsuperscript{1}, T. Vepkhvadze\textsuperscript{1} and O. Vinogradova\textsuperscript{1,2}

\textsuperscript{1}Laboratory of exercise physiology, Institute of Biomedical problems of Russian Academy of Sciences, Moscow, Russian Federation and \textsuperscript{2}Faculty of Fundamental Medicine, M.V.Lomonosov Moscow State University, Moscow, Russian Federation

The PGC-1\textalpha is a master regulator of mitochondrial biogenesis in skeletal muscle. The expression of PGC-1\textalpha-b mRNA via the alternative promoter plays an important role in exercise-dependent expression of PGC-1\textalpha gene. The goal of the study was to investigate a role of AMPK in regulation of PGC-1\textalpha gene expression via the alternative promoter in endurance-trained skeletal muscle. We investigated activation of AMPK and PGC-1\textalpha gene expression via the alternative promoter before and after acute endurance exercise, with or without administration of a single dose of metformin, well known AMPK activator. In order to improve metformin delivery to skeletal muscle, the exercise bouts were performed when the level of metformin in the blood was near maximal. On the other hand, to avoid exercise-induced activation of AMPK, we used low-intensity exercise.

The study was approved by the Human Ethics Committee of the IBMP RAS and complied with the guidelines set forth in the Declaration of Helsinki. 9 amateur endurance-trained athletes Vo\textsubscript{2max} 56 (53–62) ml/min/kg] participated in this study. Each participant swallowed 2 g of metformin or placebo before exercise (45 min, 40% Vo\textsubscript{2max}). Biopsies from the vastus lateralis muscle were taken prior to and at 2 min, 4 h, and 8 h after exercise. Data are expressed as median and interquartile range. The Wilcoxon test was used to compare repeated measurements at level of significance \( P \leq 0.05 \).
In the experimental trial the plasma concentration of metformin prior to and just before termination of exercise was high (~ 1000 mg/l). The exercise intensity was low, and therefore did not induce lactate accumulation in the blood in the placebo trial. The phosphorylation level of AMPK$^{\text{Thr}172}$ did not change at 2 min after the exercise in either the metformin or placebo trials. However, ACC$^{\text{Ser}79/222}$ (the substrate of AMPK, i.e. an endogenous marker of AMPK activity) showed a 2.6-fold ($P<0.01$) increase in phosphorylation level at 2 min after exercise in the metformin trial only. Post-exercise expression of PGC-1$\alpha$ gene via both the alternative and canonical promoters did not differ between trials. Lack of a metformin-induced increase in PGC-1$\alpha$ gene expression via the canonical promoter under increased AMPK activity is in accordance with recent findings showing that the canonical promoter in endurance-trained human skeletal muscle is constitutively expressed, and that its expression does not depend on the intensity of exercise or intensity-dependent activation of AMPK (Popov et al., 2015). Lack of a metformin-induced increase in PGC-1$\alpha$ gene expression via the alternative promoter does not confirm a role of AMPK in regulation of PGC-1$\alpha$ gene expression in endurance-trained human skeletal muscle.


This work was supported by the Russian Science Foundation (grant 14-15-00768).

Where applicable, the authors confirm that the experiments described here conform with the Physiological Society ethical requirements.

---

PC43

**The lymphocyte secretome from young adults enhances skeletal muscle regeneration, but effects are attenuated in the secretome of older adults**

S. Al-Dabbagh$^1$, J. McPhee$^1$, C. Stewart$^2$, C. Murgatroyd$^1$ and N. Al-Shanti$^1$

$^1$School of Healthcare Science, Healthcare Science Research Centre, Manchester, UK and $^2$Research Institute for Sport & Exercise Sciences, Liverpool, UK

Older people experience skeletal muscle wasting, in part due to impaired proliferative capacity of quiescent skeletal muscle satellite cells which can be reversed by exposure to young blood. To investigate the role of immune cells, we isolated lymphocytes from whole blood of young and older healthy volunteers and cultured them with, or without, anti-CD3/CD28 activators to induce release of cytokines, interleukins and growth factors into the media. The secreted proteins were used to prepare conditioned media that was subsequently used to culture C2C12 myoblasts. The conditioned media from activated young lymphocytes increased the rate of proliferation of myoblasts by ~3-fold ($P<0.005$) and caused an approximate 4-fold ($P<0.005$) increase in migration compared with non-activated lymphocyte control media. These responses
were characterized by minimal myotube formation (2%), a low fusion index (5%), low myosin heavy chain content and substantial migration. In contrast, myoblasts treated with conditioned media from activated old lymphocytes exhibited a high degree of differentiation, evident as elongated, multi-nucleated myotube formation that was comparable to control conditions, thus showing no effect on proliferation, or migration of the activated lymphocytes from old. These results indicate that young lymphocytes secretions induce muscle regeneration by enhancing muscle cell proliferation and migration, whereas secreted proteins from lymphocytes of older people may contribute to the attenuated skeletal muscle satellite cell proliferation and migration. 

Where applicable, the authors confirm that the experiments described here conform with the Physiological Society ethical requirements.

---

**PC44**

**The impact of 8-month training preparation for an Ironman distance triathlon immune response in recreational athletes**

A.V. Tanner¹, J. Roberts² and R. Lancaster³

¹Life and Medical Sciences, University of Hertfordshire, Hatfield, UK, ²Faculty of Science & Technology, Anglia Ruskin University, Cambridge, UK and ³University of Bedfordshire, Bedford, UK

The popularity of extreme endurance events has grown over the past decade and more recreationally trained athletes are undertaking extreme events, such as long distance triathlons. However, few studies have investigated the effect of high volume triathlon training on illness risk and a high training load has been indicated as a predictor of increased risk of URTI symptoms in athletes (Gleeson et al., 2013). 61 recreational athletes (following an 8-month training plan to prepare for an Iron-distance triathlon) (IMM) and 37 recreationally active controls (CON) completed the study. At months 0, 2, 4, and 6 participants underwent an incremental exercise test to assess maximal oxygen consumption (VO₂max). For six months leading up to the race, participants completed bi-monthly nutrition and sleep diaries and weekly illness symptom and training diaries. A subset of 12 IMM and 12 CON were studied for the 8-month period before the race and provided a resting saliva sample, for analysis of secretory IgA (s-IgA) and salivary lysozyme (S-Lys) and completed diaries for a further two month period. 55 participants completed the Ironman distance triathlon in an average time of 12:58:03 ± 1:19:28. There was no significant difference in VO₂max between IMM and CON at baseline (45.9 ± 6.8 mL·kg⁻¹·min⁻¹ vs 46.2 ± 7.2mL·kg⁻¹·min⁻¹ respectively). There was a significant increase in VO₂max in IMM between 0 and 2 months (7%, p<0.05); however, no further significant changes. VO₂max did not change in CON. There was no significant difference in incidence of URTI or symptom score between months 0 and 6 in IMM or CON. There was no difference in incidence of URTI between IMM and CON, except a significantly higher symptom score in IMM at month 6 (p=<0.05). In the subset, in IMM, S-IgA secretion was significantly higher at month 8 compared to...
baseline and saliva flow rate was significantly higher at month 8 compared to month 4 (p<0.05). There was no significant change in S-IgA concentration or S-Lys concentration or secretion. The increase in VO$_{2\text{max}}$ during the first two months of initiating triathlon training indicates adaptations occurred quickly; however after month 2 increasing training load did not affect VO$_{2\text{max}}$. There was minimal difference in illness episodes scores or URTI episodes between time points or groups, this may reflect the moderate and progressive training load undertaken by IMM; which did not increase the risk of URTI. Furthermore, the increase in S-IgA secretion in the IMM group was likely to be due to changes in flow rate. Overall, it appears that 8-months of training for a long distance triathlon has no detrimental effect on the immune response in recreational athletes, but further analysis is required to examine nutritional and sleep factors.


Where applicable, the authors confirm that the experiments described here conform with the Physiological Society ethical requirements.
Further work is needed to cross-validate conventional assays used to measure biomarkers of muscular stress with the metabolomics platform to confirm that urinary trimethylamine N-oxide, citrate, glycine and hippurate are indirect biomolecular markers of muscular exercise. In sports medicine, NMR-urinalysis may provide diagnostic and prognostic information on injured and recovering athletes to determine whether or not they are fit to play, and predict risk of injury based on their current state of health.

Medicines Research Group, School of Health, Sport and Bioscience, University of East London.

School of Biological and Chemical Sciences, Queen Mary University London.

Where applicable, the authors confirm that the experiments described here conform with the Physiological Society ethical requirements.

PC46

Changes in Frequency-Domain indices after a High Intensity Interval Training acute intervention to reduce music performance anxiety

C. Blasco-Lafarga¹, P. Monteagudo-Chiner¹, N. Blasco-Lafarga², A. Cordellat¹, R. Sanchis-Sanchis¹, A. Roldán¹, A. Jiménez-Muñoz¹, A. Berruga-García² and G. Sanchis-Soler¹

¹Physical Education and Sport Department, University of Valencia, Valencia, Spain and ²Generalitat Valenciana, Primary Health Centre in Llíria-Hospital area, Llíria, Spain

The sympathetic branch arouses to sustain the adaptation to stressors, although faster parasympathetic adjustments are responsible of immediate adaptive changes (e.g. anxiety control before a demanding concert). Sometimes this vagal control fails, like in Music Performance Anxiety (MPA) (1). Recent studies showed a decrease in the High Frequency index (HF) (2), a vagal index under the indirect modulatory control of the cortical-amygdala neurocircuitry, in the basis of emotion regulation (3). These studies also reflect an increase in the LF/HF (Low Frequency/High Frequency ratio) with unclear results for the former LF (2). On the other hand, the High Intensity Interval Training (HIIT) has been associated to a vagal improvement and a reduction of the sympathetic arousal in long-term interventions (4), but little is Known about short acute proposals. This study aims to analyze the changes in the frequency indices of HRV after one week of HIIT in a group of young musicians facing a demanding concert. 12 healthy male wind-instrumentalists (23±4.88y; 78.86±11.46kg) performed two concerts in one week. 48h after the first concert they underwent a graded cycling test until voluntary exhaustion (15-W increase per 1-min, Tacx flow ergometer, Tacx, Wassenaar, Netherlands) for high intensity familiarization and medical supervision. 48h later, musicians conducted 2-to-4 30-s cycling all-out Wingates, interspersed with 4 min of recovery (187.90±12.25 bpm; 11.70±3.38 mmol/L-¹ lactate; 9.60±1.07 RPE on Borg 10 scale). 5 min of a 10-min Heart Rate recording in sitting-position (Polar
rx800), were retained twice for HRV analysis (Kubios, 2.1): fasting in the morning, in baseline condition (BS), and immediately before the concert (BC). Wilcoxon test showed BC pre-post training changes in LF/HF ratio (p<0.05; 3.05±2.75 vs 1.68±1.29 ms²), and a slight trend toward a significant improvement in HF (p=0.07; 1119.50±1356.96 vs 2097.94±2868.36 ms²), with no significant differences for LF (1870.15±2386.33 vs 2154.34±2148.79 ms²). The improvement was no significant in BS (LF/HF: 2.76±3.56 vs 1.51±1.07 ms²; HF: 2872.67±3324.60 vs 3308.11±3641.26 ms²; LF: 3444.06±3523.09 vs 3212.49±2824.80 ms²). Despite the short time of the intervention and the reduced sample, our results support the hypothesis that the parasympathetic reactivation and the better vagal balance following HIIT (5) might be helpful in the control of MPA. LF/HF ratio and HF, which were susceptible to extraordinary stressful events (2), are also susceptible to benefit from acute HIIT interventions. New studies will show if longer recovery following exercise might show BS vagal reactivation. Lack of time among professional musicians might suggest that HIIT is a short-term efficient solution for MPA.


Thanks to La primitiva, L’Amistat & La Paz (Musicians); Quart & Siete Aguas Town-Halls.

Where applicable, the authors confirm that the experiments described here conform with the Physiological Society ethical requirements.
Static and dynamic postural changes after a mountain ultra-marathon of 80 Km and 5500 d+

G. Marcolin\textsuperscript{1}, A. Grainer\textsuperscript{1}, C. Reggiani\textsuperscript{1}, P. Bisiacchi\textsuperscript{2}, G. Cona\textsuperscript{2}, N. Petrone\textsuperscript{3} and A. Paoli\textsuperscript{1}

\textsuperscript{1}Department of Biomedical Sciences, University of Padova, Padova, Italy, \textsuperscript{2}Department of General Psychology, University of Padova, Padova, Italy and \textsuperscript{3}Department of Industrial Engineering, University of Padova, Padova, Italy

The study aimed to investigate the effect of fatigue on static and dynamic postural control after finishing a mountain ultra-marathon race. Twelve male athletes participated at the study. Postural stability was assessed before and immediately after the race. Bipodalic standing balance was measured on a dynamometric platform with eyes opened (OE) and closed (CE). Dynamic test was performed with OE on an instrumented plate which allowed medio-lateral oscillations. Stabilometric data were affected by fatigue in the OE condition, concerning sway path ($p=0.0006$), sway area ($p=0.0006$), area of the confidence ellipse ($p=0.0016$), maximal AP ($p=0.0017$) and ML ($p=0.0039$) oscillations. In the CE condition the sway path ($p=0.0334$), the maximal ML oscillations ($p=0.0161$) and the area of the confident ellipse ($p=0.0180$) were also negatively influenced. Stabilogram diffusion analysis showed in the OE condition an increase of short-term diffusion coefficients considering the anterior-posterior direction ($D_{fys}$; $p=0.0023$) and the combination of the two directions ($D_{fr^2}s$; $p=0.0032$). Equally, long term diffusion coefficients increased considering the anterior-posterior direction ($D_{fyl}$; $p=0.0093$) and the combination of the two ($D_{fr^2}l$; $p=0.0086$). In CE condition greater values were detected for medio-lateral ($D_{fxl}$; $p=0.033$), anterior-posterior ($D_{fyl}$; $p=0.0459$) and the combination of the two ($D_{fr^2}l$; $p=0.0048$). Dynamic test showed an increase of the time spent with the edges of the plate on the floor ($p=0.0152$). These results suggest a more marked involvement of cognitive resources to monitor postural stability after fatiguing. This caused a worsening in the automatic task (quiet standing) and a positive compensation in the less automatic task (dynamic test).

Where applicable, the authors confirm that the experiments described here conform with the Physiological Society ethical requirements.
The effects of selective breeding and endurance training on the maximum aerobic exercise metabolism in bank voles

M. Dzialo, E.T. Sadowska and P. Koteja

Institute of Environmental Sciences, Jagiellonian University, Kraków, Poland

Problem: It is known that nature (genetic factors) and nurture (environmental factors) influence physiological performance traits, such as the aerobic capacity. An intriguing question is whether and to what extent a genetically determined superior performance is mediated by an increased propensity to the effects of training.

Purpose: The aim of this study was to check whether long-term artificial selection (20 generations) for increased maximum rate of aerobic metabolism achieved during voluntary exercise (swimming; VO2swim), which resulted in about 50% increase of VO2swim, improved also the effect of training of aerobic performance traits in bank voles (Myodes glareolus).

Methods: Males from four selected (A) and four unselected, control (C) lines (32 individuals from each type of lines) were randomly assigned to two groups (at the age of 51-56 days). In one group the animals were subject to interval training three times a week for 8-weeks. Each training session consisted of ten 2.0 min cycles, and each cycle comprised three phases: 0.5 min of “active rest” (running at 1 km/hour), 0.5 min of speeding up, and 1 min running at sub-maximal speed (2.5-4.1 km/h; chosen individually, based on preliminary trials). Animals from the second group were sedentary, but were accustomed to the treadmill. At the beginning and the end of experiment measurements of the maximal rate of forced-running exercise metabolism (VO2max) and endurance running distance (ERD) were performed. All the protocols were approved by the Local Ethical Committee in Kraków (decision 66/2012).

Results: Analysis of covariance showed that training had no effect on body mass (F1,6=1.18, P=0.32), but at the end of experiment voles from the A lines had a higher body mass than those from C lines (adjusted least-square means (LSM)±SE: A: 26.4±0.4 g, C: 22.7±0.7 g; F1,6=8.05, P=0.03). Selection resulted in increased post-training VO2max (mass-adjusted LSM±SE, A-lines: 5.1±0.1 ml O2/min; C-lines: 4.1±0.1 ml O2/min, F1,6=37.13, P<0.01) and a higher ERD (A-lines: 1824±180 m, C-lines: 1206±180 m, F1,6=7.71, P=0.03). However, training had increased only endurance (trained: 1938±176 m, sedentary: 1163±170 m; F1,6=18.40, P<0.01), without changing level of VO2max in either type of lines (F1,6=0.30, P=0.61). The selection × training interaction was not significant for any of the traits.

Conclusion: This experiment showed that selection (nature) was effective in increasing the aerobic performance traits, but did not increase effect of training (nurture). Interestingly, the results revealed that ERD has been improved despite the fact that VO2max remained unchanged. This suggest that endurance running in bank vole may not be limited by VO2max.

Where applicable, the authors confirm that the experiments described here conform with the Physiological Society ethical requirements.
The influence of dehydration on long-term heat acclimation and temperate exercise

R. Neal, H. Massey, M.J. Tipton and J. Corbett

Sport and Exercise Science, University of Portsmouth, Portsmouth, UK

The ergogenic potential of heat is contentious\cite{1}. Long-term (≥ 10 day) heat acclimation (HA) has been shown to be ergogenic under cool ambient conditions with mechanisms underpinning this including increased maximal oxygen uptake, possibly mediated by plasma volume (PV) expansion and an increased maximal cardiac output\cite{2}, as well as reduced physiological strain through improved thermoregulation\cite{3}. Recently, short-term (5 day) HA with restricted fluid intake has been shown to augment PV expansion and accelerate HA relative to euhydrated HA\cite{4}; performance improvements in the heat have been documented in trained men following this regime\cite{5}. This study examined the effect of dehydration on long-term HA and exercise performance in a temperate environment.

A within-participant, balanced cross-over design with a three-month wash-out period was employed. Each participant completed both control (euhydrated HA [HAeu]) and intervention (HA with permissive dehydration [HADe]) conditions; achieved by completely restricting fluid intake in the isothermic strain HA sessions; a total of 1.75 L of fluid was provided during each control session. All procedures adhered to ethical standards of the Human Tissues Act and the University’s Ethics Committee and with the Declaration of Helsinki. Eight males (Mean[SD] age 21[3] years; maximal oxygen uptake [VO2max]: 55.1[7.1] mL.kg\(^{-1}\).min\(^{-1}\); peak power output [PPO]: 338[46] W; training: 10[3] hours.week\(^{-1}\)) undertook a long-term HA programme (T\(_{amb}\) = 40 °C, 50% rh) with a euhydrated Heat Stress Test (HST) (60 mins cycling at 35% PPO, preceding, mid-way though, immediately following and one week after HA (HA consisted of eight isothermic strain sessions: 90 mins. day\(^{-1}\), target rectal temperature [Tre] of 38.5-38.7 °C). A graded exercise test (GXT) for determination of blood lactate threshold (LT), VO2max and PPO was performed in a temperate environment (22 °C, 50% rh) pre- and post-HA.

HA induced adaptation when exercising in the heat (Table 1), although there were no differences in the extent of HA between HAEu and HADe, except for the maintenance (Post- to Decay-HA) of a greater Δ blood volume in the HAEu condition (7.0[5.6%]) compared to a return to baseline from Post- to Decay-HA in the HADe condition (P<0.05). HAEu and HADe reduced thermal and cardiovascular strain similarly in a temperate environment following long-term HA and an improvement in oxygen pulse was also observed (P<0.05). Performance trials in a temperate environment suggest that PPO was improved following long term HA but did not differ between conditions and VO2max and LT were unaltered.

HA induced favourable thermal, thermoregulatory, physiological and cardiovascular responses to exercise in hot and temperate environments in trained men.
However, the rate of HA was not improved with dehydration as an additional stimulus and the ergogenic benefits of HA were unsupported.

<table>
<thead>
<tr>
<th>HST variable</th>
<th>Mid-HA</th>
<th>Post-HA</th>
<th>Decay-HA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal strain</td>
<td>↓</td>
<td>↓</td>
<td>↓</td>
</tr>
<tr>
<td>Cardiovascular strain</td>
<td>↓</td>
<td>↓</td>
<td>↓</td>
</tr>
<tr>
<td>Physiological strain</td>
<td>↑</td>
<td>↑</td>
<td>↔</td>
</tr>
<tr>
<td>Perceptual strain</td>
<td>↔</td>
<td>↑</td>
<td>↓</td>
</tr>
</tbody>
</table>


Where applicable, the authors confirm that the experiments described here conform with the Physiological Society ethical requirements.

PC50

**Lifelong exercise is associated with greater age-related motor unit remodelling**

A. Ireland¹, M. Piasecki¹, J. Coulson¹, A. Hamilton-Wright², D. Stashuk³, D. Jones¹ and J. McPhee¹

¹School of Healthcare Science, Manchester Metropolitan University, Manchester, UK, ²School of Mathematics and Computer Science, Mount Allison University, Sackville, NB, Canada and ³Department of Systems Design Engineering, University of Waterloo, Waterloo, ON, Canada

In vastus lateralis (VL), around ~40% of motor units (MUs) are lost by age 70 even in active older men, whilst remaining MUs are around 25% larger due to collateral reinnervation of orphaned fibres (Piasecki et al. 2015). This remodelling is accompanied by reduced stability (indicated by increased MU potential (MUP) variability, or ‘jiggle’) and firing rate in remaining units. There is some evidence that exercise is effective in attenuating MU loss (Power et al., 2010), although it is unknown whether remodelling is affected. Therefore, intramuscular electromyographic signals were recorded at proximal and distal motor points of (VL) in 26 young males (age 25±5y), 22 old males (71±5y) and 15 Master athletes (MA, 70±6 yrs) during contractions at 25% of knee extension maximum voluntary contraction (MVC).
Data were analysed using decomposition-based quantitative electromyography (DQEMG) to identify characteristics of individual MUPs, resulting in 698, 627 and 414 detected MUPs in young, old and MA respectively. Jiggle was assessed following application of a ‘near fibre’ method to examine only contributions from fibres located very close to the electrode, thereby reducing artefact or attenuation. Group effects were assessed using one-way ANOVA, with Bonferroni-corrected posthoc tests used to locate group differences. Firing rates were normally distributed and are reported as mean(SD). MUP size and jiggle were not normally distributed; they were log transformed prior to analysis and are presented as median(IQR). Median MUP size was 62% and 18% larger in MA than young and old respectively, whilst old median MUP size was 37% larger than young (Table 1, all $P<0.001$). Jiggle and firing rate did not differ between old and MA (both $P>0.5$), but values in both groups were higher and lower respectively than in young (all $P<0.05$). Regular exercise does not prevent age-associated MU remodelling. Conversely, remodelling is more pronounced in highly active older males but this is not accompanied by greater slowing of MUs or MU instability above that observed in healthy ageing. Exercise participation may improve effectiveness of reinnervation following MU loss, contributing to preservation of muscle size and strength in older age.

Table 1

<table>
<thead>
<tr>
<th>Variable</th>
<th>Young</th>
<th>Old</th>
<th>Master Athlete</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area ($\mu$V ms)</td>
<td>1108 (690-1656)</td>
<td>1335 (947-1993)**</td>
<td>1660 (1117-2695)**†</td>
</tr>
<tr>
<td>Jiggle (%)</td>
<td>23.9 (19.7-29.6)</td>
<td>26.4 (20.7-33.4)**</td>
<td>25.6 (20.5-33.6)***</td>
</tr>
<tr>
<td>Firing rate (Hz)</td>
<td>9.8 (2.2)</td>
<td>8.7 (2.2)**</td>
<td>8.7 (2.5)**</td>
</tr>
</tbody>
</table>

Table 1. Motor unit potential (MUP) characteristics separated by group. Asterisks indicate significant difference from young males: *$P<0.05$, **$P<0.001$. Dagger indicates significant difference from old males: †$P<0.001$.


This work was supported by funding from UK Medical Research Council (MR/K025252/1).

Where applicable, the authors confirm that the experiments described here conform with the Physiological Society ethical requirements.

---

**PC51**

**Post exercise hypotension after interval and continuous exercise**

Z.L. Incledon, M.G. Hughes, B. Chant and J. Whitaker

*Cardiff School Of Sport, Cardiff Metropolitan University, Cardiff, UK*

Exercise training has been shown to mediate acute and chronic decreases in blood pressure. Post exercise hypotension (PEH) has been deemed clinically significant, as it can be utilised by individuals with hypertension to lower BP for up to 24 hours.
PEH has also been implicated in blood volume changes (Hayes et al., 2000). The current exercise guidelines for hypertension are 30 minutes of continuous low-moderate exercise five times a week. There has been a recent increase of reports in the literature supporting positive health and performance benefits following periods of high intensity exercise training (Gibala et al., 2012). However, the literature lacks clarity about whether PEH is affected by exercise intensity. Work by Hecksteden et al. (2013) implied that there was a relationship between PEH and the chronic BP reduction upon completion of a training programme. Therefore, PEH may give a prediction into the likely hypotensive benefits following a training programme. With this in mind the aim of this study was to compare the PEH response following acute high intensity interval training (HIT), modified sprint interval training (mSIT) and continuous endurance training (ET) sessions.

The acute blood pressure response was compared between a HIT session (4x4 minute at 90% VO$_{2\text{max}}$, with 3 minutes recovery at 50% VO$_{2\text{max}}$) similar to that used by Helgerud et al. (2007), a mSIT session (60 seconds at 100% of VO$_{2\text{max}}$ interspersed with 75 seconds at 50% of VO$_{2\text{max}}$) previously used by Little et al. (2010) and a continuous training session (CT) (30 minutes at 50% VO$_{2\text{max}}$). Blood pressure was measured in 12 active normotensive participants (Age: 21 ± 1.7 years, Mass: 79.6 ± 14.7 kg, VO$_{2\text{max}}$: 45.2 ± 7.5 ml/kg/min) before, during and in the 60 minutes following exercise. Changes in plasma volume were also predicted. In the 1-hr post exercise the reduction in systolic blood pressure was significantly greater following HIT (10.4mm Hg, p < 0.05) compared to mSIT (5.3mm Hg) and ET (1.6mm Hg). No differences were found in diastolic blood pressure during recovery (P > 0.05). There was no significant difference in percentage plasma volume change between the three intensities (P > 0.05).

The results of this study show that exercise intensity has an effect on the PEH response, with HIT eliciting a significantly larger drop in BP than mSIT and ET. HIT decreased SBP by 9mm Hg more than ET, considering that a 2mm Hg difference in BP can be deemed clinically significant, current exercise recommendations for hypertension should expand to include HIT. Future study should focus on hypertensive individuals in a carefully monitored clinical setting.


I would like to thank Dr. Michael Hughes for his excellent support, guidance and mentoring throughout all of my studies. I would also like to thank Ben Chant and Jazmine Whitaker, this data was collected as group and without their hard work would not have been possible.

*Where applicable, the authors confirm that the experiments described here conform with the Physiological Society ethical requirements.*

---

**PC52**

**Post exercise hypotension after high intensity interval exercise - comparison of upper and lower body exercise**

M.G. Hughes, C. Williams and P. Smith

*Cardiff School of Sport, Cardiff Metropolitan University, Cardiff, UK*

The recovery from exercise leads to ‘post-exercise hypotension’ (PEH) which can persist for some hours, thus providing potential benefits for managing hypertension. Most PEH research has used lower body cycling, however in some populations this may not be a viable mode of exercise and greater knowledge about the comparative responses between exercise modes may provide insight into the mechanisms underpinning PEH. The few studies which have compared PEH in upper and lower body activities have either used activities unsuited for training (maximal tests)\(^1\) or have failed to control for the relative exercise intensity (i.e., \(\%VO_2\text{max}\)) between the two modes of exercise.\(^2\) Therefore the aim of this study was to examine the blood pressure response after arm crank (ARM) ergometry and conventional leg cycling (LEG). In keeping with the developing interest in high-intensity interval exercise, the LEG-ARM comparison was made using the interval training model of Wisloff et al. (3).

After ethical approval, nine young, recreationally active, normotensive participants (6 male, 3 female; age 20.2 ± 1.2 years; maximal oxygen consumption 46 ± 12 ml/kg/min; baseline blood pressure (systolic / diastolic) 129 ± 12 mmHg / 80 ± 10 mmHg) volunteered for the study. Maximal exercise tests were carried out each using ARM and LEG ergometry. Subsequently, intensities were derived for interval sessions of 4 x (4min at 90-95% HRpeak: 3 min at 70% HRpeak) based on the mode-specific peak heart rate. Manual blood pressure, obtained pre-exercise (baseline) and then for 60-min during recovery (15 min intervals), was the primary outcome and statistical comparisons were made using 2-way repeated measures ANOVA.

Mean \(VO_2\) (2.34 ± 0.57 vs. 1.70 ± 0.42 l/min; \(P<0.001\)) and power (237 ± 68 vs. 115 ± 37W; \(P<0.001\)) were higher during LEG than ARM intervals, while blood lactate (5.6 ± 1.8 vs. 4.7±0.9 mM; \(P=0.132\)) was not different. Mean systolic blood pressure (SBP) was reduced in recovery (\(P=0.019\)) by 10 ± 1 mmHg (LEG) and 7 ± 1 mmHg (ARM) with no difference between exercise modes (\(P=0.423\)) and no (time*mode interaction) (Figure 1). Diastolic blood pressure was not reduced post-exercise following either mode of exercise.
With the current procedures, both exercise modes reduce SBP during the 60-min recovery, highlighting the efficacy of interval exercise using either ARM or LEG as a potential stimulus for blood pressure management. The similar PEH, in the face of significantly different power and VO$_2$, may support the likely importance of local factors in the regulation of PEH.

Figure 1. Systolic blood pressure (SBP) after a high intensity interval session using arm and leg cycling.

Wisloff U et al. (2009). Exercise and Sports Science Reviews. 139 - 146.

Where applicable, the authors confirm that the experiments described here conform with the Physiological Society ethical requirements.

PC53

Sex differences in human eccentric hamstring strength and Biceps Femoris long head architecture

T. Maden-Wilkinson$^1$, R. Moody$^1$, F. Behan$^{1,2}$, T.G. Balshaw$^{1,2}$ and J.P. Folland$^{1,2}$

$^1$School of Sports, Exercise and Health Sciences, Loughborough University, Loughborough, UK and $^2$Arthritis Research UK, Loughborough University, Loughborough, UK

Hamstring strain injuries (HSI) are the most prevalent non-contact injury in many sports with the Biceps Femoris long head (BFhl) reported as being the most commonly injured muscle. Reported incidence rates among professional male athletes are considerably higher than among professional female athletes (1). Eccentric strength and shorter muscle fascicle length (FL) are known risk factors for HSI (2,3), but whether these contribute to the sex difference in injury risk is unknown. This study aimed to examine the sex difference in eccentric strength and FL.
Thirty recreationally active participants (15 males; 23 ± 3 yrs, 75 ±10 kg, 1.79 ± 0.07 m; 15 females; 21 ± 1 yrs, 62 ± 7 kg, 1.68 ± 0.07 m) with no previous history of hamstring strength training were assessed for maximal eccentric strength using a Nordic hamstring rig. Participants were positioned with strain gauges attached 2cm above both lateral malleoli. Following a structured warm up, participants were instructed to control their fall until they could no longer resist the increasing gravitational moment of the exercise and fall to the floor. This break point angle was quantified using video recordings synchronized with the force trace (0°= full extension) and analysed manually using video analysis software (Kinovea, France Ver. 0.8.15). Participants performed 3-5 maximal contractions with visual and verbal feedback. Maximal eccentric torque was calculated by the mean of the maximal force produced at both legs, and normalised relative to lever length and body mass (Nm.kg⁻¹). B-mode ultrasound using a 92mm probe was performed to quantify muscle thickness (MT), pennation angle (PA) and muscle fascicle length (FL) of the BFlh at 50% muscle length.

Relative maximal eccentric torque produced during the NHE was significantly greater in Males (1.55 ± 0.25 Nm.kg⁻¹) than Females (0.95 ± 0.18 Nm.kg⁻¹) (p<0.001) with the break point angle significantly lower in males (47 ± 11°) than Females (58 ± 11°) (p<0.01). In terms of muscle architecture of the BFlh, males had significantly greater MT (Males: 28.9 ± 6.3 mm; Females: 22.5 ± 4.4mm, p<0.01) and a steeper PA (Males: 20.0 ± 5.5°; Females: 15.7 ± 2.6°, p=0.011), however there was no significant difference between males and females for muscle FL (Males: 89.1 ± 20.8mm; Females: 89.8 ±19.5mm, p=0.919). There was a weak relationship between break point angle and relative force in both sexes (r=0.23-0.28, p<0.05).

These data suggest that the sex differences in HSI injury prevalence could partly be attributed to differences in muscle architecture and eccentric hamstring strength.


The authors wish to thank the participants of the study.

*Where applicable, the authors confirm that the experiments described here conform with the Physiological Society ethical requirements.*
Active GSK3 and a functional β-catenin-TCF4 transcriptional complex are necessary for the differentiation of human myogenic progenitor cells

C.C. Agley¹,², F.C. Lewis¹, O. Jaka¹, C. Velloso¹, N. Lazarus¹, G.M. Ellison-Hughes¹ and S.D. Harridge¹

¹Centre of Human & Aerospace Physiological Sciences, King’s College London, London, UK and ²Wellcome Trust - Medical Research Council Cambridge Stem Cell Institute, University of Cambridge, Cambridge, UK

Canonical Wnt-β-catenin signalling is essential for skeletal muscle myogenesis during development, but its role in adult human skeletal muscle repair and regeneration remains unknown. Binding of Wnt ligands at the cell surface disables the capacity of GSK3 to phosphorylate β-catenin thus preventing its degradation and stimulating its interactions with TCF transcription factors. Here we manipulated a number of the molecular players in the Wnt signalling cascade in adult primary human skeletal muscle progenitors to assess their role in differentiation. Muscle biopsy samples were obtained from the vastus lateralis of healthy young male subjects (25.5±(SD) 3.1 years) following local anaesthesia (2% lidocaine). Muscle-derived cells were isolated and expanded in culture for 7 days after which CD56pos myogenic cells were immunomagnetically purified (Agley et al. 2013). Myogenic cells were either maintained in growth medium or stimulated to differentiate in serum-free conditions. In addition to studying β-catenin expression levels and localisation during differentiation, the following were applied in order to manipulate Wnt signalling: (i) pharmacological GSK inhibition, (ii) Lentiviral overexpression of constitutively active β-catenin (EβC) or (iii) dominant negative TCF4 (dnTCF4). Cells were analysed using western blotting, immunocytochemistry and qRT-PCR. Although detectable in growth medium, active β-catenin was mainly cytoplasmic. Under serum-free differentiating conditions active β-catenin stained strongly in the nucleus of differentiated MHCpos myotubes. Inhibition of GSK via BIO (5µM) increased active-β-catenin (Control: 45.8±8.0 (AU); BIO: 105.2±4.0 (AU); P<0.05), but severely blunted the normal differentiation response with marked and significant reductions in fusion index (Control: 73.1±3.7 %; BIO: 5.5±4.0%; P<0.001), individual myotube size and myogenin expression. Two further structurally diverse GSK inhibitors (CHIR-99021 and LiCl) produced very similar effects. EβC gave a milder phenotype of reduced fusion and myotube size although myogenin and MHC were still expressed. Contrastingly, loss of β-catenin-dependent TCF-driven transactivation (dnTCF4) entirely prevented fusion of myogenic precursors and myogenin expression was absent. Discrepancies between GSK3 inhibition and β-catenin overexpression reveal that active GSK3 is essential for myogenic fusion and differentiation with roles which likely extend beyond the regulation of β-catenin stability alone. Although greatly increasing nuclear β-catenin decreases myogenic cell fusion, disruption of its transcriptional co-activator role completely abolishes differentiation. Together these data show that active GSK3 and a functional β-catenin-TCF4 transcriptional complex are necessary for the differentiation of adult human myogenic progenitor cells.
Neural and morphological contributions to the individual changes in explosive and maximal strength following a 12-week training intervention period

T.G. Balshaw¹,², G. Massey¹,², T. Maden-Wilkinson¹, N. Tillin³ and J.P. Folland¹,²

¹School of Sport, Exercise, & Health Sciences, Loughborough University, Loughborough, UK, ²Arthritis Research UK Centre for Sport, Exercise and Osteoarthritis, Loughborough, UK and ³University of Roehampton, London, UK

Whilst group level changes in neural drive and muscle hypertrophy have been widely reported after strength training (Tillin et al., 2011, 2012; Erskine et al., 2012), the contributions of these adaptations to individual changes in strength are poorly understood. The purpose of this study was to assess the contribution of underlying physiological adaptations (neural, intrinsic contractile properties, muscle size and architecture) to the functional changes in explosive and maximal strength following training.

Thirty-five healthy young males completed explosive strength training (EST, n=12), conventional strength training (CST, n=13), or control (CON, n=10) for 12 wks. Training involved 4 x 10 knee extension repetitions (x3/wk); contracting “as fast and hard as possible” for ~1 s (EST); or gradually increasing to 75% of maximal voluntary torque (MVT) before holding for 3 s (CST). Functional and physiological changes were measured pre and post. Knee extension torque (T) and quadriceps EMG were measured during maximum voluntary (MVT and EMG@MVT) as well as explosive voluntary (EMG₀-₅₀, ₀-₁₀₀, ₀-₁₅₀) and evoked contractions (T at 50 ms increments, T₅₀,₁₀₀, and T₁₅₀). Quadriceps muscle volume (QVOL, via MRI), pennation angle and fascicle length (via ultrasound recordings) were also determined. Pearson’s product moment bivariate correlations and, when multiple predictor variables were correlated with the outcome, stepwise multiple linear regressions were calculated between strength changes (ΔMVT, ΔT₅₀, ΔT₁₀₀, ΔT₁₅₀) and the changes in physiological predictor variables.

ΔMVT was correlated with ΔEMG@MVT (r=0.553, P=0.001) and ΔQVOL (r=0.608, P<0.001) but none of the other predictor variables (r≤0.216, P≥0.213). ΔT₅₀ and ΔT₁₀₀ were only correlated with ΔEMG₀-₅₀ (r=0.730, P<0.001) and ΔEMG₀-₁₀₀ (r=0.561, P<0.001), respectively. ΔT₁₅₀ was correlated with ΔEMG₀-₁₅₀ (r=0.667, P<0.001) and ΔMVT (r=0.550, P=0.001). Stepwise regression with ΔQVOL (37%) and ΔEMG@MVT (17%) explained a combined 54% of the variance in the ΔMVT. ΔEMG₀-₁₅₀ (44%) and ΔMVT (10%) in combination explained 54% of the variation in ΔT₁₅₀.

In conclusion, improvements in MVT were explained primarily by ΔQVOL, with a smaller contribution from changes in neural drive. In contrast, changes in early phase explosive
torque production (0-100 ms) were explained exclusively by changes in neural drive. Changes in late phase explosive force production were also largely explained by changes in neural drive but with a contribution from changes in MVT.


Where applicable, the authors confirm that the experiments described here conform with the Physiological Society ethical requirements.

---

**PC56**

**The relationship between Patellar tendon stiffness, rate of torque development and maximum isometric torque**

J. Quinlan¹, M.V. Franchi¹, N.J. Szewczyk¹, B.E. Phillips¹, P.L. Greenhaff¹, P.J. Atherton¹, K. Smith¹, C. Maganaris² and M.V. Narici¹

¹University of Nottingham, Derby, UK and ²Liverpool John Moores University, Liverpool, UK

Tendons are viscoelastic anatomical links between muscles and bones; Their primary role is the transmission of contractile force onto a joint, to enable movement. To fulfill this role, tendons must be sufficiently stiff. Mechanical stiffness is important when considering the role of either tendon or aponeurosis on the mechanical output of muscle contraction (1). It has previous been shown that the Vastus Lateralis aponeurosis stiffness is positively correlated to the rate of torque development (RTD) (2), however it is also important to consider the in series patellar tendon, since it is this tendon which is distally attached to the tibia, thus enabling knee extension movement. In addition it is known that tendons adapt to the mechanical loading they habitually undergo, by becoming stiffer or more compliant when chronic loading increases or decreases, respectively (1). The research has investigated the relationship between: 1) patellar tendon stiffness and rate knee extension torque development ,(RTD) and 2): patellar tendon stiffness and knee extension maximal voluntary contraction (MVC).

Eight healthy young males (24±5yrs, 174±4cm, 72.38±10kg) were recruited for an 8 week training study. Baseline measures of patellar tendon stiffness derived from combining dynamometry and ultrasound scanning in vivo, knee extension MVC and RTD were obtained at 90° knee joint angle. RTD was assessed at 3 time variables 0 - 50ms, 0 - 200ms and 0 - 2/3 maximal force (F2/3). Pearson’s correlation was applied to the variables with a significance level of P<0.05. Patellar tendon stiffness, assessed at both maximal force and the highest common force to all participants, was significantly correlated to RTD obtained at 0-50ms (r²=0.75 and 0.58 respectively). However,
this correlation was absent at either of the later time points, 0-200ms or 0-F2/3, when compared to patellar tendon stiffness at maximal or highest common force. Nonetheless, patellar tendon stiffness at maximal force and highest common force was also significantly correlated to MVC (r²=0.70 and 0.69 respectively). The above results indicate that tendon stiffness is an important contributing factor in the early stages of force transmission (50ms), which indicates that after the first 50ms as the tendon is pulled by the muscle, the tendon becomes an effective mechanical link for contractile force transmission and joint movement. Additionally, the high correlation between tendon stiffness and MVC indicates that differences in tendon stiffness largely reflect the differences in the maximum tensile force applied by the in-series muscle, despite maximum muscle forces not being applied often in daily activities. It is of interest to establish whether the proportionality between stiffness and MVC also applies between tendon and muscle dimensions.


Where applicable, the authors confirm that the experiments described here conform with the Physiological Society ethical requirements.

---

PC57

**Chronic beta₂-adrenergic stimulation induces oxidative-to-glycolytic and slow-to-fast twitch transition of skeletal muscle and attenuates training-induced increases in rate of Ca²⁺ uptake of the sarcoplasmic reticulum following 11 weeks of resistance training in active young men**

S. Jessen¹, A. Kalsen¹, M. Kreiberg¹, J. Onslev¹, N. Ørtenblad², V. Backer¹, J. Bangsbo³ and M. Hostrup¹

¹Department of Respiratory Research, Bispebjerg University Hospital, Copenhagen, Denmark, ²Department of Sports Science and Biomechanics, University of Southern Denmark, Odense, Denmark and ³Department of Nutrition, Exercise and Sports, Section of Integrated Physiology, University of Copenhagen, Copenhagen, Denmark

Chronic stimulation of β₂-adrenoceptors increases Ca²⁺-handling, and induces shifts myosin heavy chain(MHC) I to MHCII isofrom and from an oxidative to a glycolytic phenotype in animals. However, no study has investigated the additive effect of β₂-adrenoceptor stimulation and resistance training in humans. In the present study we investigated the effect of 11 weeks of resistance training alone or in combination with β₂-adrenergic stimulation on sarcoplasmic reticulum (SR) Ca²⁺ handling and MHC isofrom distribution, as well as on oxidative and glycolytic enzymatic activity of skeletal muscle in young men. Twenty-six trained men were randomized to either placebo (PLA) or oral salbutamol (4×4 mg×d⁻¹, SAL). Subjects completed a supervised 11-week resistance training intervention three times pr. week. Before and after the intervention, MHC isofrom distribution, SR Ca²⁺ handling, and maximal activity of CS, HAD, PFK, LDH, and CK were measured in biopsies
collected from the vastus lateralis muscle. In SAL, MHCIIa isoforms increased (P≤0.05) by 6±5% (mean±95%CI) with the intervention, whereas MHCI isoforms decreased (P≤0.05) by 6±6%. MHC isoform distribution did not change with the intervention in PLA. Rate of Ca²⁺ release increased (P≤0.05) in both groups with the intervention (SAL: 2.6±0.5 to 2.8±0.5 Ca²⁺×min⁻¹×g⁻¹×protein⁻¹; PLA: 2.5±0.5 to 2.8±0.5 Ca²⁺×min⁻¹×g⁻¹×protein⁻¹). In SAL, time constant of Ca²⁺ uptake was unchanged with the intervention (-6%), whereas it was 14% lower (P≤0.01) after the intervention in PLA compared with before. In SAL, maximal activity of CS decreased (P≤0.01) with the intervention (32±3 to 29±3 µmol×g dw⁻¹×min⁻¹), whereas no change was observed in PLA (29±3 to 30±3 µmol×g dw⁻¹×min⁻¹). Likewise, maximal activity of HAD decreased (P≤0.001) with the intervention in SAL (24±2 to 20±2 µmol×g dw⁻¹×min⁻¹), while no change was observed in PLA (22±2 to 22±2 µmol×g dw⁻¹×min⁻¹). Maximal activity of LDH increased (P≤0.001) with the intervention in SAL (463±83 to 524±83 µmol×g dw⁻¹×min⁻¹), whereas no change was observed in PLA (515±83 to 535±83 µmol×g dw⁻¹×min⁻¹). Maximal activity of PFK and CK did not change with intervention in either group. In conclusion, β₂-adrenergic stimulation induces muscle fiber type transition towards a fast twitch glycolytic phenotype following resistance training. Furthermore, β₂-adrenergic stimulation attenuates resistance training-induced increases in Ca²⁺ uptake function.

Where applicable, the authors confirm that the experiments described here conform with the Physiological Society ethical requirements.

PC58

Real-time monitoring of driver’s autonomic regulation in formula-one racing

P.O. Julu¹ and G. Zenios²

¹Cardiovascular Research Centre, Queen Mary University of London, London, UK and ²Extreme Biometrics, Tunbridge Wells, UK

Every second is valuable in formula-one (F1) racing, so it requires real-time monitoring of performance. While the mechanical aspects of the race can be monitored, there is currently no appropriate method for monitoring brain controls of human functions during racing. We have investigated the role of cardiac vagal tone (CVT) in F1 racing because of the importance of central parasympathetic restraint during both mental and physical challenges.

We asked a Red Bull Racing F1 driver to volunteer as a subject to be monitored during practice in a simulator equipped with all aspects of F1 racing except the moments of inertia forces (G-force). He was wearing the full racing suite with helmet, but we added the Neurozoid wireless electrocardiogram (ECG) sensors placed in a conformation of modified Einthoven Lead II position (Neurozoid, Extreme Biometrics, Tunbridge Wells, Sussex, UK). The Neurozoid fed the ECG to a cloud-based processor via a wireless mobile device for the measurement of CVT in real-time using the NeuroScope method previously described in details (Julu et al., 2003). The CVT is measured in clinically validated, atropine-derived units of
Poster Communications

the Linear Vagal Scale (LVS, Julu 1992) and data is sent back from the cloud-based processor to the telemetry desk of the race Engineer in real-time. The driver carried out two drives of ten laps each separated by 30 minutes of rest period in a simulated Yas Marina race circuit in Abu Dhabi. This race tract is notorious for its long high-speed straights ending with sharp bends requiring intense and heavy braking. The pre-race CVT remained above 30 LVS units at the start of both drives, but was quickly withdrawn to below 5 LVS units when the driver pulled from the pit to the race track (Fig.1). The normal range of resting supine CVT in sedentary non-athletes is 5-10 LVS units (Mckechnie et al., 2002). The CVT remained below 5 units during racing except when driving on the long high-speed straights when it recovered briefly to levels above 15 LVS units only to be quickly withdrawn again to levels below 10 LVS units during the sharp bends at the end of the straights (Fig.1). The CVT responses were consistent during the two drives (Fig.1).

Real-time changes in CVT can be monitored continuously during F1 racing and it consistently matched the task being performed by our F1 volunteer driver, where intense engagements caused vagal withdrawals to the extents that reflected the speed and intensity of the tasks being performed. The pre-race CVT level in the driver was nearly threefold that in sedentary people. We propose that the extent of CVT withdrawal can be used as a physiological measure of engagement and or perceived difficulty of a task in F1 racing. This can be interpreted as a measure of the perceived stress while performing a particular task.

Two examples of cardiac vagal tone (CVT) responses during formula-one (F1) racing involving driving through long straight tracks (S) at full throttle and ending in a sharp bends (B) that require heavy braking and concentration. Note the rapid withdrawal of CVT as the car pulls off at the start of the race and the recovery of CVT during the straight parts of the track. This recovery is halted at sharp bends by sudden withdrawal of CVT and the recovery resumes at another segment of a long straight track. This is consistently repeated in all segments of the racetrack with long straights ending with sharp bends.


Where applicable, the authors confirm that the experiments described here conform with the Physiological Society ethical requirements.
The effect of chronic beta_2_-administration on exercise-induced increase in maximal oxygen uptake

J. Onslev¹,², N. Krogh¹,², V. Backer¹, J. Bangsbo² and M. Hostrup¹,²

¹Department of Respiratory Research, Bispebjerg Hospital, København NV, Denmark and ²Department of nutrition, exercise and sports, August Krogh Institute, Copenhagen, Denmark

Chronic high-dose beta_2_-agonist administration has been shown to decrease skeletal muscle citrate synthase and cytochrome oxidase C activity in both endurance trained and sedentary rats, which could have deleterious effects on the oxidative capacity. Indeed, this effect has later been connected to a diminished exercise performance measured by time to exhaustion on a treadmill. Furthermore, a shift in fibre type towards a more glycolytic phenotype in response to chronic beta_2_-agonist administration has been demonstrated, both indicating increased dependence on anaerobic metabolism of the skeletal muscle cells. Whether or not this is also the case in humans and at therapeutic doses is unknown.

The effect of chronic beta_2_-agonist on exercise performance and oxidative capacity was examined in a 4-week randomized, double-blinded, controlled study. Twenty one subjects was included in an active group (TER, n = 12) and a placebo group (PLA, n = 9). Throughout 4 weeks of endurance training TER received 8 x 0.5 mg terbutaline by inhalation daily. Before and after the intervention the maximal oxygen consumption (VO_2_-max) was measured in an incremental cycling test. Furthermore, time to exhaustion (TTE) was assessed in a relative resistance cycling test corresponding to 120% of VO_2_-max (120%-VO_2_-max-test).

A significant (P ≤ 0.01) interaction effect of group*time was observed for VO_2_-max. VO_2_-max was higher in PLA than in TER (4153±133 vs. 3990±154 ml/min) after the intervention compared with before the intervention (3904±128 vs. 3965±149 ml/min). Furthermore, a significant (P ≤ 0.001) within-group time effect was seen in PLA on VO_2_-max (3904±128 vs. 4153±133 ml/min), whereas the VO_2_-max remained similar for TER (3965±149 vs. 3990±154 ml/min). Also, during the VO_2_-max-test the incremental peak power output (iPPO) was increased by 19±13W (P ≤ 0.01) and 38±15W (P ≤ 0.001) with the intervention in TER and PLA resulting a significant (P ≤ 0.05) interaction effect (20±19W). Lastly, the results from the 120%-VO_2_-max-test revealed a significant (P ≤ 0.05) interaction on group*time on TTE, where TTE was greater in TER than in PLA after the intervention (165,9±21 vs. 131,4±18 s) than before the intervention (127,8±17 vs. 146,1±19 ml/min). This is accompanied by a significant (P ≤ 0.05) within-group time effect in TER (127,8±17 vs. 165,9±21 ml/min).

We conclude that therapeutic doses of inhaled terbutaline blunts the endurance training-induced increase in VO_2_-max. Furthermore, the increase in iPPO in TER unaccompanied by a corresponding increase in VO_2_-max points towards an increased anaerobic energy contribution. Also, this conclusion is supported by the
120%-VO$_2$-max-test, which shows an increased TTE in TER. Overall, results indicate that the muscle cells decreases its oxidative capacity while increasing its anaerobic energy contribution going towards a more glycolytic phenotype.

Where applicable, the authors confirm that the experiments described here conform with the Physiological Society ethical requirements.

---

Expiratory muscle fatigue following upper-body exercise in healthy humans

N.B. Tiller$^{1,2}$, I.G. Campbell$^{3}$ and L.M. Romer$^{1}$

$^1$Division of Sport, Health and Exercise Sciences, Brunel University London, London, UK, $^2$Academy of Sport and Physical Activity, Sheffield Hallam University, Sheffield, UK and $^3$School of Life and Medical Sciences, University of Hertfordshire, Hertfordshire, UK

Introduction: The diaphragm and abdominal muscles exhibit contractile fatigue in response to sustained, high-intensity, whole-body exercise. We hypothesized that upper-body exercise would increase the contribution of the thoracic muscles to the control of trunk stability, and leave the diaphragm and abdominal muscles susceptible to contractile fatigue. Methods: Seven healthy, physically active men (peak upper-body O$_2$ uptake [VO$_{2peak}$], 31.9 ± 5.3 mlkg$^{-1}$min$^{-1}$; mean ± SD) performed arm-crank exercise to the limit of tolerance at work rates equivalent to 30% (Tlim; 24.5 ± 5.8 min) and 60% (Tlim; 9.8 ± 1.8 min) of the difference between gas exchange threshold and VO$_{2peak}$ (i.e. heavy and severe intensities). Diaphragm and abdominal muscle fatigue were assessed by measuring the change from baseline in potentiated transdiaphragmatic and gastric twitch pressures (P$_{di,tw}$ and P$_{ga,tw}$) in response to cervical and thoracic magnetic stimulation, respectively. Results: Tidal transdiaphragmatic pressures were elevated during heavy and severe exercise (33 ± 11 vs. 53 ± 13 cmH$_2$O, $p = 0.002$), due to equivalent changes in gastric and oesophageal pressure. There was limited evidence of diaphragm fatigue following either trial. However, 5 of 7 participants exhibited >15% reduction in P$_{ga,tw}$ at 5-15 min after severe exercise, with a mean reduction of 22 ± 18% ($p = 0.038$) and moderate effect size ($h^2 = 0.36$); values had partially returned to baseline at 25-35 min after exercise (~15 ± 15%; $p = 0.066$). Conclusions: We present preliminary evidence that the abdominal muscles (but not the diaphragm) fatigue in response to sustained, high-intensity upper-body exercise in healthy, physically active men. Since upper-body exercise induced submaximal cardiorespiratory stress, the fatigue observed was likely due to additional (non-respiratory) loading of the thoracic complex.

Where applicable, the authors confirm that the experiments described here conform with the Physiological Society ethical requirements.
Training with os acromiale: How blood flow restriction training supported the rehab process in sprint kayak

J. Coe and M. Thompson

EIS, Manchester, UK

Background: Os Acromiale is a failure of fusion of the acromial process, seen in around 8% of the population (Kurts et al. 2006). The os acromiale has been implicated as a risk factor for the development of impingement syndrome, when an os acromiale is unstable; the downward pull of the deltoid reduces subacromial space. As a result traditional strength training can be disturbed. There is a growing body of literature surrounding blood flow restriction resistance exercise (BFRRE) demonstrating rapid gains in muscle cross sectional area (CSA) and functional strength (Neilsen et al. 2012) similar or even greater extent (Takarada et al. 2002) as seen with heavy-load resistance training. Generally thought to be the results of multiple local and systemic factors (Widegren 2000). BFRRE offers a unique training modality due to its relatively low load (≥50% 1RM) reducing the stress on surrounding joint and bone structures.

Purpose: The primary aim of the study was to investigate if blood flow restricted exercise is an effective strategy to increase posterior cuff capacity and CSA around the shoulder girdle when range of motion and training intensity is limited.

Participant: 21 year old female, weight 73.4kg, height 173.8cm. Informed consent and BFRRE risk assessment was completed prior to intervention.

Methods: Intervention: 6 weeks of unilateral (affected arm only) BFRRE. In total, 18 sessions were completed in a periodised design. The first block consisted of 9 (3 sessions per week on non-consecutive days) sessions of half range bench pull at 30% 1RM and reverse fly, 4 sets to failure with 60s rest. The second block consisted of half range press ups and supine pull, 4 sets to failure with 60s rest. The first session of each block was an introductory session of 1 set of 20 reps and 3 sets of 15 reps. The occlusion cuff was placed at the proximal as high up the arm as possible and inflated to 100mmHg. Between blocks one and two, a one week ‘flush out’ was included.

Measures: Pre and post the intervention anthropometry was assessed according to ISAK along with the posterior cuff capacity test (Moore, Uhl & Kibler 2013).

Results: The anthropometry results demonstrate an increase in bicep girth from 32.1cm pre to 33.0cm post (+2.7%) and a 0.7cm increase in shoulder girth (0.6%). With no change in body mass (73.4kg vs 73.1kg). Total volume load during the first block increased from 144 reps to 169 reps (14%) in bench pull and 65 reps to 94 reps (30%) supine pull during the second block. A meaningful 21% increase in posterior cuff capacity (40 reps Vs 51 reps) was observed.
Practical Implications: With those who are unable to complete traditional resistance exercise, BFRRE was an effective strategy to induce muscle hypertrophy and endurance. Changes in posterior cuff capacity suggest local muscular endurance changes proximal to the cuff and therefore potential implications for rehabilitation when access to specific musculature is limited.


British Canoeing

*Where applicable, the authors confirm that the experiments described here conform with the Physiological Society ethical requirements.*
Does the menstrual cycle affect temperature sensitivity of muscle force?

J. Bieles

King’s College London, London, UK

Maximum voluntary force (MVF) exerted by thumb adduction (TA) declines with skin cooling, with greater decrements in post-menopausal vs. pre-menopausal women\(^1\). TA MVF is affected by the menstrual cycle, with increases of ~10% during the follicular stage when oestrogen levels rise\(^2\), although similar effects were not observed in handgrip strength\(^3\). Intrinsic hand and forearm muscles contribute to handgrip strength, which declines when both are cooled\(^4\). However, the effect of hand cooling alone has not been reported. The aim of this study was to determine the effect of hand cooling on TA and handgrip strength during the menstrual cycle. We hypothesised that: i) hand cooling would reduce TA MVF to a greater extent than handgrip; ii) cooling effects are greater when oestrogen levels are lower.

17 healthy women (18-42 yrs) with regular menstrual bleeds not using hormonal contraception, volunteered to attend twice: 7-10 days after the start of the menstrual cycle when oestrogen levels are high, and after the luteinizing hormone peak, when oestrogen levels are low. The hand was cooled and warmed (skin temperatures 12-40\(^\circ\)C) in a water bath. TA MVF and maximal handgrip strength were measured at 4-minute intervals and normalised to the subject’s mean at skin temperatures >35\(^\circ\)C. A 2-way rANOVA was used to determine the effect of temperature and menstrual status. Post-hoc t-tests were performed across temperature bins. A-priori power calculation suggests a sample size of 40 is required to establish an effect of menstrual cycle upon the effect of cooling on strength. These preliminary data show pre-ovulation TA MVF is higher than post-ovation (p=0.017). At skin temperatures <20\(^\circ\)C MVF is lower than when >20\(^\circ\)C (p=0.001). Handgrip strength at skin temperatures <25\(^\circ\)C is lower than those >25\(^\circ\)C, pre- and post-ovation (p<0.001) irrespective of menstrual phase. There was no interaction between temperature and menstrual cycle for handgrip strength or TA MVF.

The decline in handgrip strength with hand cooling occurred at a higher temperature (25\(^\circ\)C) than for TA MVF (20\(^\circ\)C). This is despite the fact that forearm muscles were not directly cooled, suggesting mechanisms other than local muscle cooling contribute to the decline in handgrip strength. TA MVF, but not handgrip, was lower post-ovation suggesting an influence of female hormonal status may have been observed when the muscles were cooled directly. Further data is required to determine if there is an interaction between temperature and menstrual cycle phase on force.