

This article was downloaded by: [EBSCOHost EJS Content Distribution - Current]

On: 9 December 2009

Access details: Access Details: [subscription number 916903244]

Publisher Routledge

Informa Ltd Registered in England and Wales Registered Number: 1072954 Registered office: Mortimer House, 37-41 Mortimer Street, London W1T 3JH, UK



Journal of Sports Sciences

Publication details, including instructions for authors and subscription information:

<http://www.informaworld.com/smpp/title~content=t713721847>

Sixth International Conference on Sport, Leisure and Ergonomics: 14-16 November 2007

To cite this Article (2009) 'Sixth International Conference on Sport, Leisure and Ergonomics: 14-16 November 2007', Journal of Sports Sciences, 27: 1, S1 – S35

To link to this Article: DOI: 10.1080/02640410902761199

URL: <http://dx.doi.org/10.1080/02640410902761199>

PLEASE SCROLL DOWN FOR ARTICLE

Full terms and conditions of use: <http://www.informaworld.com/terms-and-conditions-of-access.pdf>

This article may be used for research, teaching and private study purposes. Any substantial or systematic reproduction, re-distribution, re-selling, loan or sub-licensing, systematic supply or distribution in any form to anyone is expressly forbidden.

The publisher does not give any warranty express or implied or make any representation that the contents will be complete or accurate or up to date. The accuracy of any instructions, formulae and drug doses should be independently verified with primary sources. The publisher shall not be liable for any loss, actions, claims, proceedings, demand or costs or damages whatsoever or howsoever caused arising directly or indirectly in connection with or arising out of the use of this material.

ABSTRACTS

Sixth International Conference on Sport, Leisure and Ergonomics: 14–16 November 2007

Effects of a blinded change in ambient temperature on human performance and the thermoregulatory responses to exercise

G. Atkinson¹, C. Jackson¹, B. Drust¹,
W. Gregson¹, & A. St Clair Gibson²

¹Research Institute for Sport and Exercise Sciences, Liverpool John Moores University, Liverpool, UK and ²School of Psychology and Sport Sciences, Northumbria University, Newcastle, UK

Using a novel single-blind protocol, we examined the effects of two different hot conditions on self-selected power output and the thermoregulatory responses to exercise lasting 5.5–6.5 min. Eight males, aged 21–40 years, completed two 4-km time trials in an environmental chamber set at 30°C (T_{30}) and 35°C (T_{35}). Participants were told that they were exercising at the same ambient temperature of 32.5°C on both occasions for the purposes of a reproducibility study. Without feedback to participants, power output, core (intestinal) temperature, mean skin temperature and heart rate were measured throughout each time trial. Ratings of thermal discomfort and perceived exertion (RPE) were also recorded. Data are presented as mean \pm s and 90% confidence limits (90%CL). Power output was 14 ± 18 W lower in T_{35} compared to T_{30} over the first 1 km of the time trial (90%CL = 3–25 W, $P = 0.047$). Between-trial differences in power output over the remainder of the time trial were not statistically significant. The difference in overall 4-km time (377 ± 18 in T_{35} vs. 381 ± 22 s in T_{30}) was also trivial (90%CL = -3 to 11 s, $P = 0.30$). Core temperature, mean skin temperature and thermal discomfort were $0.2 \pm 0.2^\circ\text{C}$, $1.4 \pm 0.3^\circ\text{C}$ and 0.5 ± 0.6 units higher during exercise in T_{35} compared to T_{30} ($P < 0.05$). The rise in mean skin temperature during exercise was also significantly ($P = 0.05$) steeper in T_{35} ($0.009 \pm 0.02^\circ\text{C} \cdot \text{min}^{-1}$) than in T_{30} ($0.0003 \pm 0.01^\circ\text{C} \cdot \text{min}^{-1}$). Differences between trials in heart rate and RPE were not statistically ($p > 0.44$), nor practically, significant.

These data suggest that individuals are able to “detect” higher thermal discomfort when blinded

ambient and body temperatures are also higher throughout an exercise period lasting 5.5–6.5 min. Nevertheless, this higher thermal discomfort at 35°C vs. 30°C was accompanied by a lower power output only during the first few minutes of exercise. We conclude that there are behavioural influences on the extent to which different ambient and body temperatures affect power output during a 4-km time trial.

Influence of a fatiguing session of alt violin playing on the 3D arthrokinematics of the support and bow arm

J. P. Baeyens^{1,2}, P. Felix¹, S. Truijien¹, & D. Vissers¹

¹Department of Health care Sciences, University College of Antwerp, Antwerp, Belgium and ²Experimental Anatomy, Vrije Universiteit Brussel, Brussels, Belgium

This report is part of a pilot study to evaluate by means of dynamic EMG and motion tracking complex motions and local stress involved in violin playing. Four alt violin students without musculoskeletal complaints were recruited from the Royal Flemish Conservatory of Antwerp. Electromagnetic tracking data were obtained with an extended range Flock of Birds (Ascension Technology) and converted to anatomically defined Euler/Cardan angles of scapulothoracic, humeroscapular and forearm-humerus movements following the recommendations of the International Society of Biomechanics. The procedure consisted of a 3 min. evaluation partiture, followed by a 20 min. fatiguing partiture and ended with the initial 3 min. evaluation partiture. The bow and the support arm were separately evaluated with partitures, unknown to the students, specifically compiled by the alt violin tutor with emphasis of spiccato for the bow arm and vibrato for the support arm. Means and standard deviations of pre- and post-situations were compared by means of Kolmogorov Smirnov test, an F test and non-paired t -test. Small but significant ($P < 0.01$) decreases in

the standard deviations presented for all Euler/Cardan angles of the scapula, humerus and forearm in all subjects, both for support as well as for bow arm. For all the subjects, the 20' fatiguing violin playing induced in the bow arm more anterior tipping ($4.3^\circ \pm 3.1^\circ$), less medial ($5.4^\circ \pm 1.9^\circ$) and more upwards rotation ($16.2^\circ \pm 6.9^\circ$) of the scapula, more external rotation ($4.4^\circ \pm 1.7^\circ$) of the humerus and less flexion ($12.1^\circ \pm 7.1^\circ$) with less pronation ($12.9^\circ \pm 11.1^\circ$) of the forearm. The support arm presented with significantly ($P < 0.01$) more anterior tipping ($4.7^\circ \pm 2.6^\circ$) and more upwards rotation ($8.5^\circ \pm 5.8^\circ$) of the scapula, more internally oriented plane of motion ($16.8^\circ \pm 4.9^\circ$), more elevation ($8.7^\circ \pm 6.2^\circ$) and more external rotation ($7.8^\circ \pm 5.6^\circ$) of the humerus.

Influence of diurnal variation on performance and selected physiological actors in adolescence boy swimmers

E. Bambaiechi, N. Rahnama, & H. R. Sadeghipour

*Faculty of Physical Education and Sports Sciences,
University of Isfahan, Isfahan, Iran*

Keywords: *Diurnal variation, heart rate, temperature, swimming record*

The influence of time of day upon many physiological and performance-related variables has been well established. Both biological functions and performance of exercise demonstrates circadian rhythms. Athletes usually achieve their top performance in the late afternoon or early evening closely in phase with the peak value of core temperature. Very few studies are available on the effect of circadian rhythms or diurnal variation in swimming performance. Therefore, this study aimed to investigate the effect of diurnal variation on 100 m front crawl swim records and selected physiological factors in junior swimmers.

Thirteen males elite swimmers (Mean \pm s; age 15.5 ± 2.5 years, mass 66 ± 2 kg, height 1.77 ± 0.9 m) volunteered for this study. All subjects had been swimming for at least 5 ± 1.5 years. They trained 4 h daily (06:00 to 08:00 in the morning and 18:00 to 20:00 h in the evening) for 6 days in week, in the competitive season.

Body temperature, heart rate, diastole and systolic pressures and shoulder flexibility (flexion and internal rotation) were measured two times a day (06:00 and 18:00 h), before and after the swim tests. To decrease the influence of exogenous factors all data were gathered in one day. Performance in the swim test was significantly better at evening (58.57 s) compared to morning (59.17 s) ($P < 0.05$). In the

resting position, before doing the swim tests, the mean body temperature, heart rate, diastole and systolic pressure in the evening were higher than in the morning, but this difference was only significant for body temperature ($P < 0.05$). After the swim tests, the means of the body temperature ($P < 0.05$) and heart rate ($P < 0.05$) were significantly higher in the evening compared to the morning. Also, diurnal variation was observed for internal rotation ($P < 0.05$). Diurnal variation was not observed for diastolic and systolic pressure ($P > 0.05$). Therefore, it is concluded that maximal swimming trials are best scheduled for evening.

A practical cooling strategy for reducing the physiological strain in firefighters performing work in a hot environment

D. Barr, W. Gregson, & T. Reilly

*Research Institute for Sports and Exercise Sciences,
Liverpool John Moores University, Liverpool, UK*

The prevention of marked elevations in body temperature is important in firefighting, because high body temperatures may hinder physical and mental performance. The aim of this study was to establish whether a practical cooling strategy reduces the physiological strain during a protocol that is relevant to physical activity during firefighting. On two occasions, nine male firefighters, aged 41 ± 7 years and with body mass = 85.7 ± 7 kg, height = 1.752 ± 0.047 m, $\dot{V}O_{2\max} = 45 \pm 5$ ml \cdot kg \cdot min⁻¹ and adipose tissue of $20\% \pm 4\%$ (mean \pm s), completed two 20-min bouts of treadmill walking (5 km \cdot h⁻¹, 7.5% gradient) in the heat [$(49.6 \pm 1.8)^\circ\text{C}$, RH $13\% \pm 2\%$] separated by a 15-min recovery period. During exercise, subjects wore firefighter protective clothing, including self-contained breathing apparatus (SCBA). In the control condition, during the 15-min recovery period, subjects removed their tunics, anti-flash hoods, gloves and SCBA and consumed a controlled amount of water at room temperature (5 ml \cdot kg \cdot min⁻¹ body weight) and rested at $\sim 20^\circ\text{C}$. In the recovery period of the cooling condition, subjects also wore a cooling vest while immersing the hands and forearms in water at $\sim 19^\circ\text{C}$. There was no significant difference between trials in any of the dependant variables during the first bout of exercise. Core body temperature [37.72 ± 0.34 vs. (38.21 ± 0.17) $^\circ\text{C}$], heart rate (HR) (81 ± 9 vs. 96 ± 17 beats \cdot min⁻¹) and mean skin temperature [$(31.22 \pm 1.04)^\circ\text{C}$ vs. (33.31 ± 1) $^\circ\text{C}$] were significantly lower following the recovery period in the cooling trial compared with the control ($P < 0.05$).

After cooling, core body temperature remained consistently lower throughout the exercise in the second bout compared to control $[(0.49 \pm 0.02)^\circ\text{C}; P=0.006]$. Mean skin temperature $(2.51 \pm 0.11)^\circ\text{C}$ and HR $(123 \pm 13$ vs. 135 ± 18 beats \cdot min $^{-1}$) were significantly lower at the start of exercise bout 2 in cooling compared with control ($P < 0.005$); these differences reduced as exercise progressed. Perception of thermal sensation was significantly lower during exercise bout 2 in the cooling trial compared with control ($P=0.024$). We conclude that a practical cooling strategy is effective in reducing the physiological strain associated with firefighting activity.

Virtual rehabilitation in cerebral palsy

G. J. Barton

Research Institute for Sport and Exercise Sciences,
Liverpool John Moores University, Liverpool, UK

Control over the pelvis and trunk (core) is a prerequisite for efficient use of the legs and arms. Training of core control has become a common treatment in physiotherapy but scientific evidence supporting its efficacy is scarce (Akuthota & Nadler, 2004: *Archives of Physical Medicine and Rehabilitation* 85(3 S1):S86–S92). Cerebral palsy (CP) is a neuro-musculo-skeletal disorder caused by damage to the immature brain around birth. The primary abnormalities affecting the pelvis and trunk in CP lead to reduced stability and control of the core which reduces mobility of distal body segments leading to inefficient performance of activities of daily living.

Despite primary damage to the central nervous system in CP, global motor function can be improved by controlled exercises. Woollacott et al. (2005: *Developmental Medicine and Child Neurology* 47(7):455–461) found that reactive balance training of children suffering from cerebral palsy on a movable platform (100 perturbations a day, for 5 days) leads to faster activation of muscles, emergence of a proximal to distal muscle activation sequence and reduced co-contractions. Ledebt et al. (2005: *Motor Control* 9(4):459–468) found that balance training improved stance and gait leading to a more symmetrical walking pattern in a group of children with hemiplegic cerebral palsy. Farmer, Butler, & Major (1999: *Physiotherapy* 85(5):242–247) were able to improve control of erect dynamic posture in an 8-year-old boy suffering from diplegic cerebral palsy using Targeted Training (Butler & Major, 1992: *Physiotherapy* 78(1):1–6), a technique which focused movement perturbations on the knee and hip joints. Crouch gait was improved as a result of

better postural control without the need to perform surgical lengthening of shortened muscles.

Specific control of the core can be addressed by combining biomechanical movement analysis with virtual reality which makes it possible to simulate functional tasks driven by movement of the pelvis. The only CAREN virtual reality system in the UK (based at LJMU) has been used to create the Magic Carpet interactive computer game, developed in collaboration with Alder Hey Children's Hospital (Liverpool) and The Movement Centre (Oswestry). This consists of a device similar to a flight simulator driven by movement of the pelvis embedded in a "serious game". In our award winning pilot study (Barton et al., 2006: *Gait Posture* 24(S2):S101–S102), we showed that the technique has great potential to be used for both training and testing core control.

Re-direction of movement perturbation by rotating around the targeted joint

G. J. Barton¹, P. B. Butler², M. B. Hawken¹, & S. E. Jarvis²

¹Research Institute for Sport and Exercise Sciences,
Liverpool John Moores University, Liverpool,
UK and ²The Movement Centre, Robert Jones and
Agnes Hunt Orthopaedic Hospital, Oswestry, UK

Targeted training is a rehabilitation technique aimed at improving the movement control of joints by stabilising the body distal to the targeted joint and providing support perturbations (Butler, 1998: *Clinical Rehabilitation* 12(4):281–293; Major, Johnson, & Butler, 2001: *Proceedings of the Institution of Mechanical Engineers Part H* 215(3):315–323). Progression by release of a more distal joint may be too challenging for more involved patients. In such cases, the ability to focus the movement perturbation on the most distal joint while reducing the stimulus acting on the proximal joints might reduce the complexity of the task. The CAREN system can be used to focus movement perturbations on individual joints (Barton, Vanrenterghem, & Lees, 2005: *Gait and Posture* 22 (Suppl. 1):50) by rotating the supporting surface around an axis of rotation which runs through the selected joint (Barton, Vanrenterghem, Lees, & Lake, 2006: *Gait and Posture* 24(4):510–514.). The aim of this study was to find out whether rotation of the body around the hip joint leads to a more focused movement perturbation when compared with the conventional rocking movement routinely used in targeted training.

One healthy female subject (age: 46 years, height: 1.64 m, mass: 55 kg) experienced two types of movement perturbations while constrained in a

targeted training frame mounted on the CAREN moving platform. By using a combination of platform translation and rotation, the rocker movement of targeted training was replicated, and separately the body was rotated around a medio-lateral axis running through the subject's hip joints (Barton et al., 2006: *Gait and Posture* 24(4):510–514.). The platform was rocked and rotated with an amplitude of 2.5°, six times each in a random order, driven by a ramp function. Reflective marker triplets on the frame, pelvis and thorax were used to compare the ranges of motion (ROM) of the hip and spine in the sagittal plane in all conditions using Vicon motion capture.

In comparison to the rocker movement, rotation of the body around the hip joints resulted in significantly reduced ROM in the hip and spine (mean \pm s: 1.4° \pm 0.3° and 6.8° \pm 1.2°, respectively, when rocking and 1.1° \pm 0.4° and 2.5° \pm 0.4° respectively, when rotating, $P < 0.05$) and a significantly increased ratio of hip-to-spine ROM (mean \pm s: 0.2 \pm 0.1 when rocking and 0.5 \pm 0.2 when rotating, $P < 0.05$).

Rotation around the targeted joint simplifies the task by minimising the antero-posterior accelerations and related proprioceptive, vestibular and visual stimuli, as indicated by the smaller ROMs. Rotation around the hip joint re-directs the focus of movement perturbation from the spine, confirmed by the increased relative contribution of the hip. The ability to rotate the next generation targeted training frame around selected joints would constitute a simplified task focused onto the newly introduced distal joint before exposing the patient to the more difficult rocker type movement.

User requirements of elite field hockey goalkeepers wearing personal protective equipment

S. Bayer & S. R. Mitchell

ESRI, Loughborough University, Sport Technology, UK

This study represents original work designed to determine the user requirements of elite field hockey goalkeepers and the opportunities for the development of enhanced design of the users' personal protective equipment (PPE). The focus of the project was to understand how enhanced design of hockey PPE can increase the performance and comfort of the end-user at a recreational and professional level both in terms of hockey, but also for participation in other sports and non-sport sectors.

Specifically, the aim of this work was to: Identify where there are user and technological opportunities and barriers to develop more effective hockey PPE.

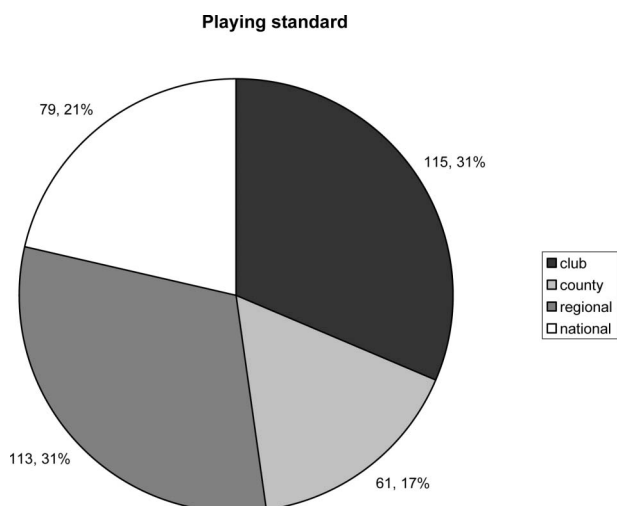
The work plan comprised of four main studies adopting a user-centred design and inter-sector knowledge transfer approach. The first study (and the focus of this article) used expertise to understand users' requirements of Hockey (sports) PPE; a web questionnaire was conducted on a user group that ranged in ability and skill level. This research provided a context of use and an insight into PPE user requirements.

The web questionnaire was designed to capture qualitative data on the PPE worn by field hockey goalkeepers. It adopted a holistic approach investigating the multi-factorial components of PPE, which included:

- The view points of the user
- The type of equipment they wear
- The tasks they are trying to achieve
- The environment they are practising in

In all, there were 389 responses to the questionnaire from a worldwide audience. It was expected that there would not be an equal gender split, as is the nature of the field hockey participation. There is a higher participation rate of males to females. Every attempt was taken to achieve a mixed response rate in ability. This was achieved through placing links to the questionnaire on web pages which are viewed by different people of varying capabilities; as a result there was a good balance from national to club level goalkeepers.

Playing standard



We received a good cross-section of playing standards throughout the sample ranging from national standard goalkeepers to club level. This is represented above.

In summary, users at the sharp end consolidated the idea that there is an opportunity to evolve

goalkeeping equipment. They identified key areas of the body that are not currently being protected well enough. Many users incorrectly perceived the relevant importance of critical items of protective equipment. This finding is concerning and relates to a change in safety awareness, perceptions and priorities. In the past, goalkeepers wore as much as possible to protect themselves but with the game becoming faster and more powerful they are now shedding equipment in an attempt to match the speed of the game. This is not an appropriate solution; instead the equipment needs improving.

The “Personal Protective Equipment in the Sports Industry” project was supported by EPSRC through the Loughborough University Innovative Manufacturing and Construction Research Centre (IMCRC). The commercial partner was PS03 Ltd.

Polymorphisms of the angiotensin-converting enzyme gene and their distribution in developing young adult Rugby Union Football players

W. Bell¹, J. P. Colley², J. R. Gwynne¹, L. Llewellyn¹, S. E. Darlington³, & W. D. Evans³

¹School of Sport, Physical Education and Recreation, University of Wales Institute Cardiff, Cyncoed, Cardiff, UK, ²Wales Gene Park, Institute of Medical Genetics, Cardiff University, Heath Park, Cardiff, UK, and ³Department of Medical Physics and Clinical Engineering, University of Wales Hospital, Heath Park, Cardiff, UK

The purpose of this study was to identify the distribution of the polymorphisms of the ACE (I/D) gene found in *developing* Rugby Union football players. A homogeneous group of 109 competitive university based rugby players and an active control group of 108 subjects were recruited over a period of 3 years. A sample of DNA was extracted from a 5 ml sample of saliva. Three-primer PCR was used to assay the region of interest for I and D variants of the ACE gene. Independent *t*-tests and χ^2 tests were used to analyse the data. Rugby players were significantly older, taller and heavier than control subjects ($P=0.003$). The proportion of genotypes for rugby players ($n=109$) was 0.21, 0.49 and 0.30 for II, ID and DD, respectively. Active controls had similar II (0.20), fewer ID (0.40), but more DD proportions (0.40), although these differences were not significant ($\chi^2=2.38$, 2 *df*, $P=0.31$, power=0.49). The proportions of genotypes of forwards ($n=56$) were 0.27, 0.43, 0.30 and of backs ($n=53$) 0.15, 0.55, 0.30 for II, ID and DD, respectively ($\chi^2=2.55$, 2 *df*, $P=0.279$,

power=0.51). When players were classified on the basis of individual/functional playing requirement differences between genotypes ($\chi^2=4.52$, 6 *df*, $p=0.607$, power=0.93) and allele frequency ($\chi^2=1.454$, 3 *df*, $p=0.693$, power=0.31) were not significant. In conclusion, it is suggested that the distribution of ACE (I/D) genotype is more balanced in *developing* Rugby Union football players, than in individual *elite* sports demanding extreme power or endurance, largely because it employs a broad variety of skills which utilise a wider range of the aerobic–anaerobic spectrum.

Ratings of perceived exertion soon after myocardial infarction; comparing responses in the stress-testing clinic and the rehabilitation gymnasium

J. P. Buckley¹, J. Sim², & R. G. Eston³

¹Centre for Exercise and Nutrition Science, The University of Chester, Cheshire, UK, ²School of Health and Rehabilitation, Keele University, Staffordshire, UK, and ³School of Sport and Health Sciences, University of Exeter, Devon UK

The purpose of this study was to compare ratings of perceived exertion (RPE; Borg’s 6–20 scale) at the same exercise intensity, between a standard exercise ECG treadmill stress test (exECG) and two subsequent bouts of treadmill exercise in a cardiac rehabilitation gymnasium. The reliability of ratings in the gymnasium was also examined. Eleven patients (mean \pm s) 60.8 ± 6.1 years performed an exECG within 12.1 ± 7.5 days after myocardial infarction (MI). The first exercise based on rehabilitation session (gym-1) was performed within 5.0 ± 1.3 days after the exECG and a second gymnasium session (gym-2) within 4.2 ± 1.3 days of gym-1. Gym-1 and gym-2 treadmill exercises were performed at an intensity that equated to the penultimate testing stage of exECG, and RPE and heart rate were compared at this level between the three test sessions. The mean work-rate at the penultimate testing stage of the exECG was 6.0 ± 1.0 metabolic equivalents (METs). The RPE values at this work-rate during exECG, gym-1 and gym-2 were 15.8 ± 2.7 , 13.3 ± 3.6 and 13.0 ± 3.4 , respectively (Figure 1). Repeated measures analysis of variance revealed these RPE responses to be significantly different ($F_{2,20}=9.8$; $P=0.001$). *Post-hoc t*-tests (Bonferroni adjusted) showed significant differences ($P<0.008$) between exECG and gym-1 and exECG and gym-2 but not between gym-1 and gym-2. Heart rates were not significantly different between the three sessions. Intra-participant agreement in RPE between gym-1

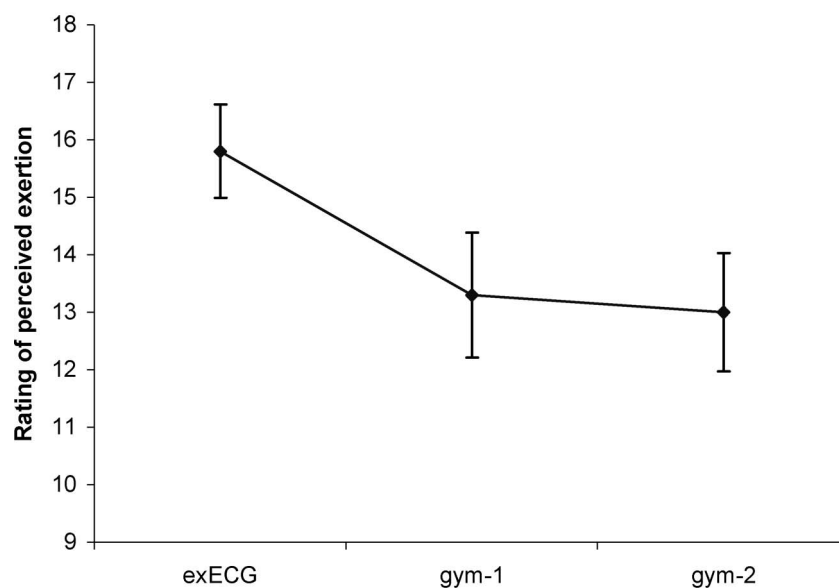


Figure 1. Ratings of perceived exertion (Mean \pm SEM), at the same work-rate (METs) during treadmill exercise performed in a post-MI ECG (exECG) clinic and during two subsequent cardiac rehabilitation exercise sessions (gym-1 and gym-2).

and gym-2 was substantial; intraclass correlation coefficient ($ICC_{2,1}$) = 0.85 (95% CI = 0.70–0.98 P = 0.0002) and in all but one participant RPEs differed by ≤ 2 scale points. Responses for RPE during standardised exECG treadmill testing, in patients soon after MI, are inflated compared to responses at the same treadmill work-rate during subsequent cardiac rehabilitation exercise sessions. Thus, caution is advised in using RPE taken from an initial exECG to guide physical activity in MI patients but introducing RPE at this point appears to contribute to its subsequent reliable use in the gymnasium.

How do healthy and diseased joints move during everyday human activities?

A. Cappozzo

Laboratory of Bioengineering, Department of Human Movement and Sport Sciences, University Institute for Movement Science, Rome, Italy

The mechanical analysis of a human joint during a function requires the gathering of quantitative information about the relative movement between the adjacent bones. This is achieved using mathematical models of the skeletal system and observable quantities. The latter quantities describe the position in an inertial frame, reconstructed using stereophotogrammetry, of points (markers) located on the subject's skin and the morphology of the portion of interest of the skeleton. The key methodological problem in the present context consists in the relative movement between markers and underlying bone

(artefact caused by the deformation of soft tissues – STA). Another error source, described in the literature with less emphasis but not less important, is associated with the low repeatability with which the anatomical axes, with respect to which the kinematic and kinetic quantities of interest are described, are identified. For these reasons, it is not surprising that recently the distinguished scientists Freeman and Pinskerova stated: “It may be hoped that the next few years will see a resolution to the question: how does the healthy and diseased knee move in the activities of daily life?” (Freeman & Pinskerova, 2005: *Journal of Biomechanics* 38(2):197–208). To contribute to their auspice and to pursue the relevant scientific objectives, joint kinematics must be estimated with a higher resolution than presently available. To this purpose, the following issues must be tackled: (1) optimal estimation of the instantaneous pose of bones in a laboratory system of reference during the execution of physical exercise using the instantaneous position of skin markers; (2) optimal estimation of the subject-specific bone morphology and determination of the relevant anatomical axes. The first issue entails the development of an estimator of bone pose which, besides using a redundant number of markers, incorporates a mathematical model of the STA identified using a non-invasive, subject-specific, approach. At present, when subject-specific bioimages are not available, anatomical data are obtained through a low resolution anatomical calibration which entails the determination, through stereophotogrammetry, of the position of the few bony landmarks that are identifiable through palpation. This procedure, although universally used, supplies totally unsatisfactory

results. Thus, the second issue calls for the development of a procedure which allows for an estimate of subject-specific bone digital models. A method will be presented that entails the acquisition through photogrammetry, eventually supplemented with an ultrasound probe, of the position of points approximating points lying on the bone surface (where the soft tissue layer is thin), in addition to internal points such as the centre of the femoral head that can be obtained using a functional approach. The bone morphology is estimated by optimally matching the digitised points to a digital template bone through a morphing and re-orientation exercise. With this method the manual identification of anatomical landmarks is substituted by an automatic procedure carried out on the bone digital model and using an *ad hoc* software. Since the entire bone is available, instead of a few anatomical landmarks, the identification of anatomical axes enjoys more flexibility and results more accurate and repeatable.

Inter-limb coordination, strength and power performances following a senior basketball match

L. Capranica¹, C. Cortis^{1,2}, M. F. Piacentini^{1,3}, C. Pesce¹, M. Olivi¹, & A. Tessitore^{1,3}

¹Department of Human Movement and Sport Science, IUSM, Rome, Italy, ²Department of Health Sciences, University of Molise, Campobasso, Italy, and ³Department of Human Physiology and Sportsmedicine, Vrije University of Brussel, Belgium

Older basketball players undergoing a training regimen of 1.5 hour · week⁻¹ showed good anaerobic characteristics and a moderate aerobic capacity (Tessitore et al., 2006: *Gerontology* 52:214–222). As senior basketball match requires high intensities, it is possible to hypothesise a decrease in the player's coordinative and all-out performances at the end of the match. Thus, the aim of this study was to verify differences in force, power, sprint, technical and inter-limb coordination performances following a basketball match in older individuals.

Before and after a friendly basketball match, 10 old players (age: 51 ± 7 years, range 42–61 years) were administered handgrip, sprint (10 m and 10 m bouncing the ball-10BB), jump (counter-movement jump CMJ) and in-phase (IF) and anti-phase (AF) inter-limb coordination (flexions and extensions of hand and foot at 80, 120 and 180 beats · min⁻¹ velocities, for 60 s maximum) tests (Capranica, Tessitore, Olivieri, & Pesce, 2004: *Gerontology* 51(5):309–315). In addition, heart rate (HR), rating of perceived exertion (RPE) and muscle pain (RMP)

were used to evaluate the intensity of their match. An analysis of variance for repeated measures ($P < 0.05$) was applied to evaluate pre–post match performances.

During the match, HR < 85% and > 85% of HR_{max} were 35% ± 32% and 65% ± 32%, of total match time, respectively. At the end of the match a significant ($P < 0.05$) increase emerged for RPE (pre: 8 ± 2 pts, post: 13 ± 2 pts) and CMJ (pre: 25.0 ± 4.6 cm, post: 28.5 ± 3.7 cm), while handgrip performances significantly ($P < 0.05$) decreased (pre: 537 ± 125 N, post: 472 ± 142 N) and technical skill was maintained (10 mBB/10 m: 1.0 ± 0.1). Interlimb coordination showed main effects ($P < 0.01$) for movement direction, velocity of execution and their interaction with pre–post experimental sessions. *Post-hoc* analysis showed a significant increase of IF 180 beats · min⁻¹ performances (pre: 27 ± 16 s, post: 50 ± 14 s) only. In fact, players succeed in accomplishing the whole IF test at 80 and 120 bpm and maintained similar pre–post performances during the AF condition (80 bpm: pre = 41 ± 25 s, post: 39 ± 25 s; 120 beats · min⁻¹: pre = 20 ± 24 s, post: 22 ± 19 s; 180 beats · min⁻¹: pre = 9 ± 13 s, post: 7 ± 8 s).

Senior basketball players proved to be able to maintain their good anaerobic and coordinative capabilities at the end of their intense match. This retention might also increase their arousal, leading to better CMJ and IF interlimb performances.

The relationship between segmental 3D-kinematics of the atlanto-axial joint during manual axial rotation mobilisation and morphological features of the alar ligaments and the lateral joint surfaces: An *in vitro* study on 20 un-embalmed specimens

E. Cattrysse¹, P. Kool², S. Probyn¹, J. P. Baeyens^{1,2,3}, J. P. Clarys¹, & P. Van Roy¹

¹Experimental Anatomy, Vrije Universiteit Brussel, Brussels, Belgium and ²Applied Mechanics, Vrije Universiteit Brussel, Brussels, Belgium, and ³Department of Health Sciences, University College of Antwerp, Vrije Universiteit Brussel

Detailed knowledge of cervical kinematics is essential to understand the implications of therapeutic and ergonomic interventions. It is for instance necessary to know how cervical and upper cervical kinematics can be influenced by more ergonomic sitting or screen positions for office workers. Whether these kinematics are predetermined by individual anatomical features and whether they can be influenced at all, is still unclear. So far no studies have been

performed on the relationship between atlanto-axial kinematics and the specific spatial features of the lateral atlanto-axial joints and the alar ligaments. It is at present not known what the most determining factors are for the segmental kinematics during manually therapeutic mobilisation of the atlanto-axial motion segment.

Twenty un-embalmed cervical spine specimens (9 male and 11 female; mean age 80 ± 11 years) were analysed. Segmental atlanto-axial kinematics were registered during manual regional axial rotation mobilisation using a 3D ultrasound based motion tracking system (Zebris CMS20). Then reference markers and anatomical landmarks were localised using a Microscribe 3D digitising system, first done in the intact specimen and secondly after segmentation. Using a mathematical transformation approach, the anatomical landmarks were reconstructed for the total specimen. Spatial features of the lateral atlanto-axial joint surfaces and alar ligaments of each specimen were calculated separately. The relationship between the anatomical features and the spinal kinematics were analysed using statistical regression-analysis techniques.

Although the range of motion of the main axial rotation and the coupled lateral bending motion component could each be predicted for about 50% by the total of 3D-anatomical features, the results were statistically non-significant. Although the anatomical features could predict almost two thirds of the variance of the cross-correlation coefficient, which has been proposed as an objective parameter to describe motion coupling patterns (Cattrysse et al., 2006: 9th international conference on 3D-human movement analysis: Valenciennes, France; Loones, 2001: *Mathematische objectivering van bewegingskoppeling tijdens actieve axiale rotatie in de cervicale wervelkolom*. Faculteit Geneeskunde en Farmacie. Brussels: Vrije Universiteit Brussel), this result was not significant either.

The range of motion of the coupled flexion-extension motion component, the ratio and the shift parameters however could be predicted for about 89, 86 and 92%, respectively by a selected set of anatomical features.

The results indicate that the data presented for characterising motion coupling in the atlanto-axial joint during manual regional axial mobilisation can only partially be explained and predicted by the specimen specific anatomy. The results thus only partially confirm previously supposed possible relationships between specific anatomical features and joint kinematics (Cattrysse et al., 2007a: *Journal of Electromyography and Kinesiology* 18:834–848; Cattrysse et al., 2007b: *Clinical Anatomy* 20:892–899; Cattrysse et al., 2007c: *Spine* 33:1503–1508).

These results may, however, open positive perspectives towards the possibilities of manual therapy interventions.

Effect of a physical activity plan and supplementary diet based on a milky product on cardiovascular health and basic functional physical conditions

M. Cepero¹, F. J. Rojas¹, J. C. De la Cruz¹, S. Romero², M. L. Zagalaz², M. Arteaga³, & J. J. Boza⁴

¹Faculty of Education Sciences, University of Granada, Granada, ²Department of Physical Education and Sport, University of Seville, Seville, ³Department of Physical Activity and Sport, University of Jaen, Jaen, and ⁴Research Department, Puleva Biotech S.A., Granada, Spain

The main aims of this study were to design, develop and apply a programme of aerobic physical activity and introduce a milky product based on satiating fat, for 8 months, with the objective of fighting pathologies and the symptoms associated with cardiovascular diseases measured by biochemical blood tests and body mass composition. The general hypothesis was that practice of the programme of systematised physical activity with a milky functional support improves cardiovascular health and quality of life, measured in adults by the senior fitness test (SFT), a blood test and an anthropometric evaluation.

The sample was formed by 196 adults. The independent variables of physical activity (two levels) and a milky product (two levels) were applied in a research design of five experimental groups. Group A ($n = 42$, control group, those people who drank the functional milk but do not change their habits of physical activity), Group B ($n = 48$, those people who drank the functional milk and began the physical activity plan), Group C ($n = 40$, those who drank skimmed milk and began the physical activity plan), Group D ($n = 36$, those who drank the functional milk and continued with the plan of physical activity begun the previous year) and Group E ($n = 36$, those people who drank skimmed milk and continued the physical activity plan begun the previous year). The dependent variables were related to anthropometric factors (body composition), tests of basic functional physical training states (SFT) and biochemical blood tests. The plan of physical activity was based on 3 h weekly programme of aquatic and terrestrial activities of an aerobic nature.

Significant improvements were found force of legs (13%)** and arms(18%)*, in the experimental groups that did physical activity (** $P < 0.01$,

* $P < 0.05$). All the groups lost weight, and there were statistically significant differences between Group B (-2.40%) and Group E (-0.35%) where the improvements in the loss of weight were 2% greater in Group B.

The sample that began the programme of physical activity and introduced satiating milk (Group B) obtained the greatest increase in physical fitness and cardiovascular measures. In conclusion, the physical activity plan based on 3 h weekly aquatic and terrestrial activities of an aerobic nature and the functional milk based on satiating fat has been effective in the improvement of health-related anthropometric measures (Body Mass, Composition), biochemistry in blood, and basic functional physical training conditions, diminishing the symptoms of cardiovascular risk according to biochemical results especially in the groups that initiated the programmed physical activity where the value of the triglycerides diminished significantly (-5.36%, groups B and C, 0.1% groups D and E, * $P < 0.05$).

Comparative ultrasound, X-ray, direct depth and skinfold data acquisition of subcutaneous adiposity

J. P. Clarys¹, S. Probyn¹, A. Scafoglieri¹, J. R. Schoysman², & M. J. Marfell-Jones³

¹Experimental Anatomy, Vrije Universiteit Brussel, Brussels, Belgium, ²Radiology Meise, Meise, Belgium, and ³Universal College of Learning, Palmerston North, New Zealand

Skinfold measure provides an estimation of subcutaneous adipose tissue at the site it is measured: using one or more skinfolds to estimate whole-body adiposity implies a series of assumptions which jeopardize a correct prediction of adiposity (Clarys, Probyn, & Marfell-Jones, 2005: *Ergonomics* 48:1445-1461). In addition, skinfolds may be technically easy and repetitive measured in the lean, but not in those with larger amounts of adipose tissue. Although the skinfold is an unreliable technique it remains a traditional and practical measure in population survey studies and public health nutrition status related body composition issues.

To evaluate an alternative method to the measurement of subcutaneous adiposity, a reference battery of direct incision depth (DID) measures of subcutaneous adipose plus skin bilaterally at eight sites on 11 male and 5 female cadavers were compared with ultrasound depth (USD) measurement and skinfolds (SF) at the same site. In parallel and on a different *in vitro* sample ($N = 13$ male and 13 female cadavers)

the direct incision depth of skin + subcutaneous adipose tissue was compared/verified against the corresponding X-ray depth (XRD) on a needle implant (1/1 scale) and at the location of the (before incision and needle implant) measured skinfolds. The third part of this study concerned an *in-vivo* comparison of the ultrasound depth and skinfold on identical marked sites ($N = 13$ male and 5 female subjects).

At all times skinfold and skin thickness after direct depth measures were measured with Harpenden Calipers, the ultrasound depth values were obtained with a Merlin 1101-BK Medical with a type 8570 transducer and a frequency of 9 MHz. Before the longitudinal X-ray (Fat Shadow low milliamp/sec technique) of the upper limb (biceps, triceps and forearm site) and the lower limb (medial thigh and medial calf site) a metal pin was implanted perpendicular to the muscle. Colour density differences on the radiography between different tissue penetrations allowed for correct distance (thickness or depth) measures. The direct depths after incision were measured with a metal ruler allowing for a precise distance interpretation between uncompressed muscle/fascia general surface and skin surface.

All data were normally distributed. Means and standard deviations for all variables were calculated with SPSS for windows version 15.0 including paired students *t*-test and Pearson's correlation coefficients. Technical error of the measurement and coefficient of variation were calculated to quantify systematic bias and random error.

Between all variables and within the three studies, the correlations were good to excellent r ranging from 0.90 to 0.98 for the USD and DID; from 0.58 to 0.74 for DID and SF; from 0.56 to 0.86 for USD and SF *in vitro* and from 0.84 to 0.91 *in-vivo*; from 0.94 to 0.99 for XRD and DID; from 0.92 to 0.94 for DID and SF and from 0.96 to 0.99 for XRD and SF.

However in terms of absolute values the various subcutaneous adipose depths and compressed distances were not always comparable e.g. significant differences ($P < 0.05$) were found between US and DID *in vitro* (for females, for males and for the whole sample), between US and SF *in vitro* (for females and for the whole sample), between US and SF *in vivo* (for females, for males and for the whole sample).

To confirm that ultrasound and eventually skinfolds are acceptable and reliable tools for the measurement of skin and subcutaneous adipose tissue, these findings would have needed to show close-to-identical readings with X-ray and direct depth techniques in combination with an almost perfect positive associated correlation. Unfortunately, this scenario did not eventuate. The only

justifiable conclusion from this investigation was that these findings suggest insufficient confidence in the ability of ultrasound to accurately predict direct subcutaneous adiposity values in individuals nor to recommend its unconditional use as a clinical or public health tool in the assessment of a nutrition status and/or adipose tissue patterning.

The interaction of prophylactic taping and dynamic exercise upon ankle range of movement and lower limb balance performance

K. Clay¹ & K. George²

¹Physiotherapy Department, Royal Liverpool University Hospital, Liverpool, UK and ²Research Institute for Sport and Exercise Sciences, Liverpool John Moores University, Liverpool, UK

Prophylactic ankle taping reduces the incidence of ankle injury. Initially this was thought to be due to restriction in joint range of motion (ROM). Joint restriction with taping is lost, however, after short bouts of dynamic exercise and thus the proprioceptive input from ankle tape may be more important. The aim of the current study, therefore, was to investigate the effect of taping alone, and combined with dynamic exercise, upon joint ROM and lower-limb balance.

Fifteen physically active physiotherapists (mean \pm s age = 29 \pm 5 years) participated in a counterbalanced, repeated measures cross-over design. Subjects were randomly allocated to a taping (TAPE) or control (CON) trial and returned for the alternate trial within 14 days. In both trials ankle ROM (goniometer) and lower-limb balance (Biodex System) were assessed across a timeline that included baseline, after ankle taping (brief rest in control trial) and after 20 min of dynamic lower limb exercise. Data were analysed by means of 2-way repeated measures ANOVA.

In the TAPE trial, ankle dorsiflexion ($6^\circ \pm 5^\circ$ to $1^\circ \pm 6^\circ$), plantarflexion ($47^\circ \pm 14^\circ$ to $30^\circ \pm 9^\circ$), inversion ($27^\circ \pm 11^\circ$ to $13^\circ \pm 8^\circ$) and eversion ($15^\circ \pm 7^\circ$ to $7^\circ \pm 6^\circ$) were significantly ($P < 0.05$) reduced. After exercise ankle ROM increased and was not significantly different from baseline in the TAPE trial. A significant main effect for timeline in overall stability index was based on a circa 1° improvement after taping and further 1° change with exercise in the TAPE trial and a 1° increase after exercise in the CON trial.

The restrictive effect of ankle taping on ROM was lost after 20 min of dynamic exercise. Lower-limb balance was significantly improved by taping and exercise, however, the small changes are of unknown clinical significance.

General fundamental movement skill development of 4- to 6-year-old pre-school children in Flanders

W. Cools¹, K. De Martelaer¹, B. Vandaele¹, C. Samaey¹, & C. Andries²

¹Department of Movement Education and Sports Training, Faculty of Physical Education and Physiotherapy (LK/BETR), Vrije Universiteit Brussel, Brussels, Belgium and ²Department of Developmental and Lifespan Psychology, Faculty of Psychology and Education, Vrije Universiteit Brussel, Brussels, Belgium

A lack of physical activity in general and among children and youth in particular is a growing concern noticeable in research, campaigns and programs. Being physically inactive is highly related to negative influences on several health related factors such as growing prevalence of obesity, increased risks of cardio-respiratory diseases, prevalence of diabetes and so on. Poor physical activity participation also threatens development of motor competence and can result in a strong decrease or fade away of participation in the sport and movement culture. Because of limited (spontaneous) movement opportunities among young children however, the fundamental movement skills may be strongly delayed or not fully developed. In addition, a shortage of physical activity can have a pernicious influence on the perception of well-being, the so-called "quality of life". In this contribution, we emphasise the development of fundamental movement skills among pre-school children because of the limited attention that is been given to this subject in the story of this issue. The age category of pre-schoolers as well as development of fundamental movement skills are seldom considered in research concerning physical activity.

A clustered sample of Flemish pre-school children ($N = 1208$, $n_{\text{boys}} = 654$, $n_{\text{girls}} = 554$) was assessed on their fundamental movement skill development with the MOT 4-6 test (Zimmer & Volkamer, 1987: *Motoriktest für vier-bis sechsjährige Kinder (manuel)*. Weinheim: Beltztest). The test features 18 test items including fine motor movement skill and gross motor movement skill items. The participating pre-school children were between 4 and 6 years of age ($M = 5.18$ years, ± 0.61). Length and weight were measured as anthropometric variables. Data were used to describe the developmental status of fundamental movement skills among Flemish preschoolers. A description of total motor composite on the motor assessment test was provided using quartiles for every half year age category. Non-parametric statistics in SPSS 15.0 were used for data analysis.

Compared with the amount of pre-school children with a higher motor quotient (6%) than the average, there was a larger amount of pre-school children with

a lower motor quotient (34.1%). There was a significant difference in the development of fundamental movement skills between boys (mdn = 91) and girls (mdn = 93) ($U = 165\ 760$, $P < 0.05$, $r = -0.07$). Children with normal BMI (mdn = 93) had significantly better motor quotients than children with higher BMI (mdn = 85) ($U = 26\ 259.5$, $P < 0.001$, $r = -0.11$).

In agreement with findings of other authors, there was a decrease in the development of fundamental movement skills among pre-school children compared with the normative data for the test.

Correlation between strength, power and inter-limb coordination across lifespan

C. Cortis^{1,2}, A. Tessitore^{2,3}, C. Pesce⁴, F. Perroni², C. Lupo², & L. Capranica²

¹Department of Health Sciences, University of Molise, Campobasso, Italy, ²Department of Human Movement and Sport Sciences, IUSM of Rome, Italy, ³Department of Human Physiology and Sports Medicine, Vrije Universiteit of Brussel, Brussels, Belgium, and ⁴Department of Education in Sport and Human Motion, IUSM of Rome, Italy

Inter-limb coordination has been related to age (Capranica et al., 2004: *Gerontology* 50 (6):399–406) and expertise (Capranica et al., 2005: *Gerontology* 51 (5):309–315), where a relationship to strength has been hypothesised. Thus, the present study aimed at verifying whether differences between active and sedentary individuals exist in inter-limb coordination, force, and power performances as a function of age and whether a relationship between these variable exists also in relation to age.

Handgrip, counter-movement jump (CMJ) and in-phase (IF) and anti-phase (AF) inter-limb coordination (flexions and extensions of hand and foot at 80, 120 and 180 beats · min⁻¹ velocities, for 60 s maximum) tests were administered to 82 active (30 young, 36 adult, 16 older) and 75 sedentary (32 young, 33 adult, 10 older) male individuals.

Counter-movement jump and handgrip performances showed significant effects ($P < 0.05$) for age, activity level, and their interaction, with active individuals always showing better performances. Significantly worst CMJ performances were found in older (active: 20.0 ± 5.1 cm, sedentary: 7.9 ± 2.3 cm; $P < 0.01$), intermediate in young (active: 23.7 ± 3.1 cm, sedentary: 20.9 ± 5.5 cm; $P = 0.02$) and best in adults (active: 36.0 ± 5.2 cm, sedentary: 31.4 ± 4.8 cm, $P < 0.01$) individuals. For handgrip, significantly better performances in adults (active: 476 ± 98 N, sedentary: 452 ± 90 N, ns), intermediate in old (active: 454 ± 111 N, sedentary: $354 \pm$

103 N; $P = 0.03$), and worst in young (active: 215 ± 41 N, sedentary: 234 ± 70 N; ns) were found. For inter-limb coordination, main effects emerged for activity level, age, mode, frequency, and the interactions activity × age, frequency × age, mode × frequency, mode × frequency × activity, and mode × frequency × age. *Post-hoc* analysis showed a significant difference for activity level only in older individuals, with better performances in active ones. No significant correlations emerged between coordination and handgrip performances. Significant correlations ($P < 0.05$) were found between CMJ and coordination performances only for active adults (IF: $r = 0.41$, AF: $r = 0.55$) sedentary older individuals (IF: $r = 0.66$, AF: $r = 0.66$).

Strength, power, and coordination performances were affected by activity level, regardless of age. Older individuals showed the worst coordination and power performances. Rather than strength, coordination is related to power performances only in active adults and in sedentary older individuals.

Heart rate and blood lactate of riders in the European Road Race Motorcycling Championship

E. D'Artibale, A. Tessitore, & L. Capranica

Department of Human Movement and Sport Sciences, IUSM of Rome, Italy

Although motorcycling performances strongly depend on both the machine's characteristics and rider's capabilities, scant data are available on the physiological profiles of riders who undergo a considerable physical load in different situations of riding (Gobbi, Francisco, Tuy, & Kvitne, 2005: *British Journal of Sports Medicine* 39:927–931; D'Artibale, Tessitore, Tiberi, & Capranica, 2007: *International Journal of Sports Medicine* 28:662–666). The aim of this study was to evaluate the physical load of official international men's road race motorcycling competitions.

Data were obtained from 34 male riders (age: 26 ± 7 years) during eight races of the 2005 European Road Race Motorcycling Championship (class: 125 GP, 250 GP, 600 cc). Subject's heart rate (HR) was recorded during all three phases of competition: Free practice (F), Qualifying session (Q) and official Race (R). Blood lactate (La) was measured at rest and after the ride. The intensity of efforts was calculated from HR recordings expressed as percentage of the subjects theoretical HR_{max} (220 age). The HR during the race was divided into three time periods (T_1 , T_2 and T_3) of equal duration. A Chi-square test was applied ($P < 0.05$) for intensity of

riding in engine sizes, phases of competition and riders' achievement (podium *vs.* off-podium). An Analysis of Variance was applied to La values.

Distribution of HR during riding showed significant differences ($P < 0.01$) between phases of competition and engine sizes. During the race, no significant differences emerged between engine sizes, with HR values $> 90\%$ of HR_{max} always most represented (125 GP: $93\% \pm 5\%$, 250 GP: $94\% \pm 7\%$, 600 cc: $93\% \pm 10\%$). However, significant differences ($P < 0.01$) emerged between T1, T2 and T3 race periods. No difference was found for rider's achievement. Peak La values after Q (5.2 ± 1.2 mM) and R (6 ± 2.1 mM) were significantly higher ($P < 0.01$) than resting values.

This study confirmed the heavy load of road race motorcycling competitions (D'Artibale, Tessitore, Tiberi, & Capranica, 2007: *International Journal of Sports Medicine* 28:662–666), independently from the rider's ability to reach the podium. Furthermore, it contributes to raise the awareness that the riders should have an adequate fitness level to maintain high speed riding and to minimise the effects of fatigue during their races.

Musculoskeletal fatigue and low-force physical activity

Michiel de Looze^{1,2}, Tim Bosch¹, & Jaap van Dieën²

¹TNO Quality of Life, Research Center Body@Work, Hoofddorp, Netherlands and ²Institute for Fundamental and Clinical Human Movement Sciences, Vrije Universiteit, Amsterdam, Netherlands

Because of the frequent use of computers at home and the widespread automation of work processes, activities involving monotonous hand/finger movements at low force levels, are increasingly common in our daily life. For example: Internet-surfing, gaming, computer work, steering and control by joy-stick, light pick-and-place tasks in industry and so on. Despite the low force level, these activities are not without risk, particularly if performed for longer periods of time. Musculoskeletal disorders in the shoulder region are frequent even in jobs with static levels of 2–5% MVC (Sjøgaard & Jensen, 2006: *In Fundamentals and assessment tools for occupational ergonomics* (vol. 1). London: International Publishing Services).

Many hypothesise that in low-force activities shoulder muscle fatigue is a pain-initiating factor (e.g. Takala, 2002: *Scandinavian Journal of Work Environment and Health* 28:211–213). If so, muscle fatigue, would be a relevant biomarker for cumulative exposure to repetitive work, and as such may help to prevent health problems.

Compared with high-force activities however, the occurrence of fatigue due to low-force activity is much less understood. In high-force work, major intramuscular changes (e.g. blood flow, water fluxes, metabolites concentrations) result in the development of fatigue, directly demonstrated by decreases in maximal muscle strength. In low-force activity only subtle changes occur and the maximal muscle strength is generally not decreased. However, this does not preclude that the contractile capability of the muscle has not been hampered (Blangsted, Sjøgaard, Madeleine, Olsen, & Sjøgaard, 2005: *Journal of Electromyography and Kinesiology* 15:138–148).

The present article addresses the fatigue in low-force activities. We first re-address the concept of fatigue. It appears to be useful to distinguish fatigue-related performance physiological and perceptual changes (Åhsberg, 1998: *Perceived fatigue related to work*. Stockholm: National Institute of Working Life). Second, the results are presented of a review on laboratory and field studies on fatigue development in low-level activities. The results elicit discussions on the measuring of fatigue at low force levels and the usefulness of well-controlled lab studies to understand the occurrence of fatigue in our daily, real-life, low-force activity patterns.

Electromyographic comparisons of squat and leg extension exercises at high and low intensities

M. J. Duncan, S. Dowdall, & D. Sammin

Newman College of H.E., Bartley Green, Birmingham, UK

The squat and leg extension exercise are widely used within strength, conditioning and rehabilitation. These exercises are often performed together in exercise programmes to promote quadriceps muscle balance and to reduce the risk of injury. However, the basis for this practice does not appear to be supported by empirical studies of muscle activation patterns during the squat and leg extension. The present aim was to investigate muscle activity during the squat and leg extension.

Following informed consent and institutional ethical approval, 10 males (mean age $\pm s = 22.7 \pm 3.4$ years), with strength training experience, participated in two experimental sessions. Within 48 h of determining one repetition maximum (1RM) for the squat and leg extension, each participant performed three repetitions of the squat and leg extension at 30 and 90% of 1RM. In all the cases, muscle activity of the Rectus Femoris, Vastus Lateralis and Vastus Medialis was collected using an online ME6000 system (MEGA

Table I. Mean \pm s of normalised (%) Root Mean Square EMG of the Rectus Femoris, Vastus Lateralis and Vastus Medialis during the squat and leg extension exercises at high and low intensities.

	Squat						Leg extension					
	Rectus femoris		Vastus lateralis		Vastus medialis		Rectus femoris		Vastus lateralis		Vastus medialis	
	M	S.D.	M	S.D.	M	S.D.	M	S.D.	M	S.D.	M	S.D.
30% 1RM	79.2	10.9	79.3	6.7	71.9	7.6	33.4	3.9	44.6	12.4	41.8	7.6
90% 1RM	113.9	19.5	102.6	20.6	107.6	18.2	109.2	22.8	101.8	19.8	100.3	17.2

Electronics LTD, Finland). The Root Mean Square EMG of each repetition was taken and averaged. This value was then normalised as a percent of the 1RM value for each exercise. Data were analysed for each muscle group using a 2 (Exercise) \times 2 (intensity) repeated measures ANOVA.

Results indicated significant exercise by intensity interactions for Rectus Femoris, Vastus Lateralis and Vastus Medialis (all $P < 0.05$ or better, partial $\eta^2 = 0.872, 0.694, 0.518$, respectively). These indicated, for all muscle groups, that muscle activity at 90% of 1RM was similar for the squat and leg extension but at 30% 1RM, leg extension muscle activity was significantly lower than muscle activity during the squat. Significant main effects for intensity (all $P < 0.01$, partial $\eta^2 = 0.859, 0.838, 0.913$, respectively) and exercise (all $P < 0.01$, partial $\eta^2 = 0.872, 0.501, 0.758$, respectively) were also evident. These results are important for training practices and rehabilitation as it suggests that, at high intensities, the squat and leg extension elicit similar levels of muscle activity whereas at lower intensities, muscle activation is maximised using the squat.

Optimising speed and energy expenditure in visually directed upper limb movements

Digby Elliott

Research Institute for Sport and Exercise Sciences,
Liverpool John Moores University, Liverpool, UK

Most of the traditional models of speed-accuracy relations and limb control are steady-state models that fail to consider the learning history and strategic approach a performer brings to a particular task environment. Recent work from our laboratory indicates that, with appropriate movement time and error feedback, a performer adjusts his/her behaviour from trial-to-trial to optimise not only speed and accuracy of performance but also energy expenditure. Because some errors are associated with greater temporal and energy costs than others, the strategic approach taken by most individuals is to plan for the

worse case scenario. The trajectories and subsequent endpoint distributes of rapid aiming movements depend on advance knowledge about the availability of afferent information for online control, as well as the relative costs associated with undershooting or overshooting the target position with the initial movement impulse. With practice in a particular movement context, a performer is able to reduce the trial-to-trial spatial variability associated with goal-directed movement through more consistent movement planning processes, as well as more rapid and efficient online control. At least part of the optimisation process appears to be related to the development of an internal model of performance against which early afferent feedback can be evaluated. This framework for examining speed, accuracy and energy expenditure in goal-directed reaching and aiming can be used to help us understand the breakdown of efficient upper limb control due to age and pathology.

Comparison of the accuracy of predicting maximal oxygen uptake from the Åstrand-Ryhming nomogram and the ratings of perceived exertion

J. Faulkner, D. Lambrick, G. Parfitt, A. Rowlands, & R. Eston

School of Sport and Health Sciences, University of Exeter, UK

The Åstrand-Ryhming (Å-R) nomogram is traditionally used to estimate $\dot{V}O_{2\max}$ from sub-maximal exercise intensities, and is still advocated by the American College of Sports Medicine (2006: *Guidelines for exercise testing and prescription (7th Ed.)*, pp. 70–73. Baltimore: Lippincott Williams & Watkins) despite large inconsistencies in its predictive utility. Recent research has shown that sub-maximal graded exercise tests (GXT), perceptually regulated by the Borg 6–20 Rating of Perceived Exertion (RPE) scale provide accurate estimates of $\dot{V}O_{2\max}$ in physically active and sedentary men and women (Eston, Lamb, Parfitt, & King, 2005: *European Journal of Applied Physiology* 94:221–227; Faulkner, Parfitt, & Eston, in press: *European Journal of Applied Physiology*). Similar

Table I. Comparison of measured and predicted $\dot{V}O_{2\max}$ for men and women of low-fitness.

	Measured	\dot{A} -R nomogram	RPE nomogram	RPE _{EST20}	RPE _{EST19}	RPE _{PROD20}	RPE _{PROD19}
Men	3.14 ± 0.08	3.15 ± 0.21	3.11 ± 0.14	3.10 ± 0.27	2.92 ± 0.25	3.00 ± 0.12	2.83 ± 0.11
Women	1.90 ± 0.08	2.35 ± 0.17*	1.86 ± 0.07	2.05 ± 0.13	1.95 ± 0.12	1.86 ± 0.11	1.77 ± 0.10

*Significant difference in measured and predicted $\dot{V}O_{2\max}$ ($P=0.008$).

findings have been demonstrated with the RPE nomogram (Buckley, Holmes, & Mapp, 1998: *Journal of Sports Sciences* 16:14–15). The purpose of the study was to assess the efficacy of predicting the $\dot{V}O_{2\max}$ with individuals of low-fitness from differing RPE protocols (estimation, production, RPE nomogram) and the \dot{A} -R nomogram.

Twenty four, healthy men and women of low fitness (36.5 ± 12.0 yrs) performed a graded exercise test (GXT) to volitional exhaustion to determine $\dot{V}O_{2\max}$ (estimation), a GXT perceptually regulated at RPE 9, 11 and 13 (production), and an \dot{A} -R test, in a randomised order. All tests were separated by a recovery period of 48 h. Linear regression analysis was used to extrapolate sub-maximal oxygen uptake ($\dot{V}O_2$) values elicited prior to and including RPE₁₃, to the theoretical (RPE 20) and peak value reported in the GXT to $\dot{V}O_{2\max}$ (RPE 19), to provide predictions of $\dot{V}O_{2\max}$ from both the estimation and production test. ANOVA revealed no significant differences between measured and predicted $\dot{V}O_{2\max}$ for men ($P > .05$), but not for women ($P < 0.05$; Table I). The \dot{A} -R nomogram significantly overestimated measured $\dot{V}O_{2\max}$ by $0.45 \text{ L} \cdot \text{min}^{-1}$ in women. The RPE provided more accurate estimates of $\dot{V}O_{2\max}$, despite participants exercising at a similar physiological (% $\dot{V}O_{2\max}$, %HR_{max}, power output) and perceptual (RPE₁₃) intensity as the \dot{A} -R test ($P > 0.05$). The results of this study provide further evidence that the RPE provides an alternative and more accurate sub-maximal method of estimating $\dot{V}O_{2\max}$ in individuals of low-fitness.

The effect of a preferred kicking foot on ground reaction force and power output during sprinting in football players

R. Foster & M. Lake

RISES, Liverpool John Moores University, Liverpool, UK

Football players tend to have a preferred foot for kicking the ball and it is plausible that this can eventually lead to the development of asymmetry in the lower limbs in terms of both strength and dynamic function, such as during sprint running. The aim of this study was to determine whether

asymmetry in kicking performance and leg strength could be related to stride-to-stride propulsive asymmetry in the lower limbs during maximal sprinting.

Sixteen sub-elite football players (age 20.4 ± 1.1 years, height 1.77 ± 0.04 m, body mass 79.2 ± 6.8 kg) were studied. Peak foot velocity during kicking was measured using a high-speed motion analysis system and knee extensor strength was measured using an isokinetic dynamometer. Power output and resultant ground reaction force (RGRF) during sprinting were recorded using a non-motorised treadmill and runway-mounted force platform, respectively.

Virtually all subjects demonstrated a preferred kicking leg asymmetry (Distal end velocity = $8.9\% \pm 2.4\%$ asymmetry) and strength asymmetry (Torque at $60^\circ \cdot \text{s}^{-1} = 5.6\% \pm 8.8\%$). Similarly, there were asymmetries present in power output ($6.0\% \pm 8.5\%$, $P < 0.05$) and RGRF ($3.0\% \pm 29\%$, $P > 0.05$) during sprinting. However, there was no correlation between functional asymmetries during sprinting and the strength and kicking velocity asymmetries.

These findings indicate that although asymmetry in leg strength and kicking performance can be observed, such asymmetric function does not appear to be transferred to maximal sprinting. Further research may be warranted to explore whether footballers are disadvantaged at all by the repeated use of a preferred foot during participation in their sport.

Which physical activity interventions best impact on children's physical self-perceptions? Results from the A-CLASS Project: A randomised controlled trial in primary school children

L. Fowweather, J. Henaghan, N. McWhannell, L. Graves, N. Ridgers, & G. Stratton

Research Institute for Sport and Exercise Sciences, Liverpool John Moores University, Liverpool, UK

Several cross-sectional studies have documented the relationship between physical activity and physical self-perceptions in children. However, few experimental trials have been conducted to provide evidence of the causal nature of this association. Moreover, little is known about which physical

activity programmes would best impact on physical self-perceptions. Therefore, the aim of this study was to explore the effects of three different physical activity interventions on physical-self perceptions in 9- to 10-year-old children.

Children ($n = 158$) from eight primary schools were recruited onto the study. Each school was randomly assigned to one of four conditions – high-intensity exercise (HIE); fundamental movement skill development (FMS); behaviour-modification programme (PASS) or a control group (CON). To assess physical self-perceptions, children completed the Children and Youth Physical Self-Perception Profile (CY-PSPP) at baseline and again following 6 months of the intervention programme. Only children who completed both assessments were included in the final analysis. The final sample therefore comprised of 140 children (HIE, $n = 34$; FMS, $n = 32$; PASS, $n = 42$; CON, $n = 32$). Delta (Δ) scores for the CY-PSPP total score and each subscale were analysed by ANCOVA, with baseline scores as the covariate. In addition, the pre-specified Minimum Clinically Importance Difference (MCID) was estimated, to evaluate practical relevance.

There were no significant differences between the CON and either the PASS or FMS group. However, participation in the HIE condition significantly benefited perceptions of physical self-worth ($P = 0.03$) and self-esteem ($P = 0.02$), when compared with the CON. In addition, potentially important benefits were found in the HIE as opposed to the CON group for the subscales of sports competence, body attractiveness, and physical strength, and for the total sum score of the CY-PSPP.

High-intensity exercise programmes appear to provide a mechanism for significantly improving children's perceptions of physical-self worth and self-esteem, and positively influencing perceived sports competence; body attractiveness and physical strength. However, programmes aimed at increasing skill competence or behaviour-modification did not influence self-perceptions.

Relationships between leisure-time energy expenditure and individual coping strategies for shift work

S. Fullick, C. Grindey, B. Edwards, T. Reilly, D. Richardson, J. Waterhouse, & G. Atkinson

Research Institute for Sport and Exercise Sciences, Liverpool John Moores University, Liverpool, UK

Thirteen to fourteen percent of European and North American workers are involved in a shift schedule which includes night work. Participation in shift work is associated with increased body mass index, prevalence of obesity and other health problems. Few

researchers have examined the physical activity habits of shift workers concurrently with the administration of the Standard Shift work Index (SSI) (Barton et al., 1990: *SAPU Memo No*: 1159). One section within the SSI is devoted to individual coping strategies for shift work. The aim is to examine the relationships between the SSI-measured coping strategies adopted by shift workers and their leisure-time energy expenditure, since it has been reported that increased physical activity is beneficial to night workers.

Ninety-five participants (24 females and 71 males) completed an adapted version of the SSI, together with the leisure-time physical activity questionnaire validated by Lamb and Brodie (1990: *Sports Med* 10:159–180). All participants (mean \pm s age: 37 ± 9 years) worked on rotating shift systems which included a period of night work. Predictors of age, time spent in shift work, gender, marital status and the overall shift work coping scores were entered into an initial exploratory step-wise multiple regression model. Leisure-time energy expenditure over a 14-day period was entered as the outcome variable. This analysis was followed up with a stepwise multiple regression of the individual coping scores for disengagement (avoidance of tackling a particular shift work-related problem). The individual coping subscales are related to social, domestic, sleep and work-related problems.

Gender ($\beta = 1713 \text{ kcal} \cdot \text{fortnight}^{-1}$, $P = 0.023$) and time spent in shift work ($\beta = 6.3 \text{ kcal} \cdot \text{fortnight}^{-1}$, $P = 0.051$) were found to be predictors of leisure-time energy expenditure, with the most experienced, male shift workers expending the most energy during leisure-time activities. A positive correlation was also found between the overall “disengagement” coping score from the SSI and leisure-time energy expenditure ($\beta = 54.6 \text{ kcal} \cdot \text{fortnight}^{-1}$, $P = 0.054$). In males, the individual disengagement subscale of sleep disturbances ($\beta = -257.6$, $P = 0.086$) was found to be negatively correlated to energy expenditure, whereas disengagement of domestic-related disturbances was found to be positively related to leisure-time energy expenditure ($\beta = 468.8$, $P = 0.001$). Nevertheless, the r -squared statistic for both these predictors in combination was quite low (14%). These disengagement indices were not found to relate to the energy expenditure of female shift workers ($P = 0.762$).

These data suggest that experienced male shift workers participate in most leisure-time physical activity. Some indices of individual coping strategy for shift work were also found to be correlates of leisure-time energy expenditure; the male shift workers with higher levels of physical activity in leisure-time “disengaged” more from their domestic-related problems, but less from their sleep-related problems.

We recommend that physical activity interventions for shift workers should be designed with careful consideration of individual domestic responsibilities and perceived disruption to sleep.

Acknowledgements

Sarah Fullick and Charlotte Grindey are funded by the National Prevention Research Initiative (<http://www.npri.org.uk>) for the project "Shift work and health: optimal timing of meals and physical activity" (Medical Research Council grant 7537).

Effect of a carbohydrate and casein protein beverage on recovery of endurance cycling capacity

F. J. Rojas¹, M. Cepero¹, A. Geerlings², J. C. De la Cruz¹, S. Romero³, & J. J. Boza²

¹Faculty of Education Sciences, University of Granada, Granada, ²Research Department, Puleva Biotech S.A., Granada, Spain, and ³Department of Physical Education and Sport, University of Seville, Seville, Spain

Endurance cycling performance, post-exercise recovery and muscle damage may be improved by co-ingestion of protein with carbohydrates, as the result of a faster restoration of muscle glycogen stores. This would increase exercise capacity following prolonged activity. In current study, we compared the effect of a carbohydrate-only beverage (CHO, 7% carbohydrate) with a carbohydrate and casein protein beverage (CHO-CP, 7% carbohydrate and 4% protein). The casein protein tested was a hydrolysed casein preparation produced by DSM Food Specialties (PeptoPro[®]).

Volunteers ($n = 15$) were well-trained cyclists who performed at least 3 days cycle training per week. They all possessed a $\dot{V}O_{2\text{peak}}$ of $> 40 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$. All volunteers performed two trials in a randomised cross-over design. At test-days, volunteers arrived at the laboratory in fasted condition. A cannula was inserted into an antecubital vein, for drawing blood samples. They cycled for 1 h at 75% $\dot{V}O_{2\text{max}}$, after which there was a recovery period of 2 h. Directly at the start of the recovery period, volunteers consumed one litre of one of the test drinks. After the recovery period, a 20 km time-trial was performed. Venous blood samples were obtained every 15 min during the 2 h recovery period and at the end of the 20 km ride. Blood was analysed for amino acids, insulin, glucagon, glucose, CPK, total, LDL, and HDL cholesterol, triglycerides and lactic acid. Time needed to perform the 20 km was recorded.

The results showed no significant differences in the 20 km ride when consuming the CHO

($1770 \pm 210 \text{ s}$) or CHO-CP ($1819 \pm 185 \text{ s}$). In this experiment, plasma levels of total, LDL, and HDL cholesterol, triglycerides, CPK and glucose were not significantly affected by treatment. Glucagon levels increased during the trial, but more on the CHO than on the CHO-CP treatment ($P < 0.05$). Lactic acid levels were stable during the trial, but increased after the second bout of exercise. Increase was higher at CHO than at CHO-CP ($P < 0.01$). Insulin tended to be higher at CHO-CP (AUC 0–120 min: $P < 0.07$). Finally, with the exception for glycine, aspartic acid and taurine, all plasma amino acid levels were significantly higher for CHO-CP than for CHO. Within the context of this experimental design, the CHO-CP drink showed more explicit physiological effects than the CHO drink, but this was not reflected in post-recovery exercise performance.

The influence of crank length on mechanical efficiency in hand cycling

V. L. Goosey-Tolfrey, H. Alfano, & N. Fowler

Department of Exercise & Sport Science, Manchester Metropolitan University, MMU Cheshire, Alsager, UK

The purpose of this study was to determine the effect of crank length on mechanical efficiency in hand cycling. Eight wheelchair dependent, high performance athletes completed four sub-maximal exercise bouts using a sports hand bike (Draft, Godmanchester, UK). Two different crank lengths (180 and 220 mm) were tested at two different cadences (70 and 85 $\text{rev} \cdot \text{min}^{-1}$) using the synchronous mode of cranking. Physiological measures of oxygen uptake ($\dot{V}O_2$), minute ventilation, blood lactate (B[La]), heart rate (HR), rating of perceived exertion (RPE) were recorded; gross (GE) and net (NE) efficiency were calculated. A two-way ANOVA with repeated measures was applied to determine the effects of crank length, cadence and their interaction on these physiological measures. Oxygen intake ($\dot{V}O_2$) was significantly lower and both GE and NE significantly higher with the 180-mm crank ($P < 0.05$). No significant main effect was found for cadence on the physiological measures ($P > 0.05$). There was a tendency for both HR and B[La] to be lower with the 180 mm crank, indicating lower physiological stress. The RPE data supported this finding, with a tendency for lower ratings with the 180 mm crank (9 ± 2 vs. 10 ± 3). The short crank length when used at 85 $\text{rev} \cdot \text{min}^{-1}$ was found to be the most efficient ($21.4\% \pm 3.1\%$). In conclusion, crank length has a significant effect on ME in hand cycling. A shorter crank length of 180 mm was found to be more efficient than the 220 mm, regardless of pedal rate during hand cycling.

Sensitivity of two uniaxial accelerometers during treadmill walking and running in children – the A-class project

L. Graves^{1,2}, K. Massey¹, G. Atkinson¹, W. Gregson¹, & G. Stratton^{1,2}

¹Research Institute for Sport and Exercise Sciences, Liverpool John Moores University, Henry Cotton Campus, Liverpool, UK and ²The REACH (Research into Exercise, Activity and Child Health) Group, Research Institute for Sport and Exercise Sciences, Liverpool John Moores University, Henry Cotton Campus, Liverpool, UK

Activity output being reported from uniaxial accelerometers shows a plateau at high running speeds in adults (Rowlands et al., 2007: *Medicine and Science in Sports Exercise* 39:716–727; Fudge et al., 2007: *Medicine and Science in Sports Exercise* 39:192–198). The purpose of this study was to compare the influence of speed on uniaxial accelerometry output of monitors worn on the hip and chest of young children during treadmill walking and running.

Three boys and seven girls (10.8 ± 0.4 years) completed repeated, progressively intense steady rate ($3.2 \text{ km} \cdot \text{h}^{-1}$, $3.2 \text{ km} \cdot \text{h}^{-1}$ 5% incline, $5.6 \text{ km} \cdot \text{h}^{-1}$, $8 \text{ km} \cdot \text{h}^{-1}$) and intermittent ($4 \text{ km} \cdot \text{h}^{-1}$, $4 \text{ km} \cdot \text{h}^{-1}$ 5% incline, $7 \text{ km} \cdot \text{h}^{-1}$, $10 \text{ km} \cdot \text{h}^{-1}$) protocols on a motorised treadmill in controlled laboratory conditions. Intermittent work to rest ratio was 30 s:15 s. Activity counts over 15-s epochs were measured by means of a hip-mounted GT1M ActiGraph and an Actiheart movement sensor located on the chest. Average activity counts, in counts per minute (cpm), were computed for each monitor at each speed from exercise data only.

From intermittent trials GT1M activity output peaked at $7 \text{ km} \cdot \text{h}^{-1}$ (7141 cpm) and decreased at $10 \text{ km} \cdot \text{h}^{-1}$ (7028 cpm). Actiheart activity output peaked at $10 \text{ km} \cdot \text{h}^{-1}$ (2317 cpm). There were no significant differences for Actiheart ($P=0.189$) or GT1M ($P=0.407$) activity counts between $7 \text{ km} \cdot \text{h}^{-1}$ and $10 \text{ km} \cdot \text{h}^{-1}$. From steady rate trials GT1M (6858 cpm) and Actiheart (2583 cpm) activity outputs peaked at $8 \text{ km} \cdot \text{h}^{-1}$. There were significant differences for GT1M ($P \leq 0.004$) and Actiheart ($P \leq 0.005$) activity counts between all speeds.

Regardless of monitor location, motion output from uniaxial accelerometers began to plateau at increasingly fast running speeds in children. On the basis of activity cut points of Nilsson et al., (2002: *Pediatric Exercise Science* 14:75–84) these speeds correspond to vigorous activity. This is attributed to the constancy and then decrease of body acceleration in the vertical plane at fast speeds. Given the high-intensity nature of children's activity, it seems Actiheart and ActiGraph accelerometers are likely to misclassify vigorous activ-

ity, resulting in underestimations of physical activity and energy expenditure.

Ergonomics research for sports and leisure clothing

G. Havenith

Environmental Ergonomics Research Group, School of Sports and Human Sciences, Loughborough University, Loughborough, UK

This article will provide an overview of research performed in our laboratory that has direct applications in the design and evaluation of sports clothing and equipment. Mostly it focuses on more encapsulating clothing types, such as mountaineering clothing and outdoor clothing in general, but the knowledge also provides input to athletic clothing design.

Most recently the research has focussed on various aspects of body mapping, charting the human body in terms of heat production and cooling zones. This combined with extensive work on body sweat production mapping, has allowed manufacturers to create clothing which shows regional variation in its properties, supporting the physiological responses. Initially, maps were obtained for the torso (running shirt design), hands (racket design) and feet (shoe/socks), developing a technique that allows sweat collection from large surfaces with minimal interference with the activity studied.

Another area of interest is that of heat transfer processes in clothing. It is generally assumed that sweat removal from the skin by wicking garments is beneficial. However, though this may be the case for comfort, recent work has shown that the cooling effectivity of such sweat may be reduced, and thus in events where heat loss is compromised such wicking may also have negative effects.

Techniques for collection of such data will be presented together with initial results.

The association of “pre-clinical” cardiovascular disease risk factors with body composition and cardiorespiratory fitness in primary school children (The A-CLASS project)

J. Henaghan, N. McWhannell, L. Foweather, T. Cable, A. M. Batterham, G. Stratton, & K. P. George

Research Institute for Sport and Exercise Sciences (REACH Group), Liverpool John Moores University, Liverpool, UK

Obesity and low physical fitness contribute to cardiovascular (CV) disease risk but their impact in

children is unclear. We assessed the effects of obesity and low physical fitness upon a range of early “pre-clinical” CV disease markers; left ventricular (LV) mass, carotid-intima media thickness (cIMT) and LV diastolic function in prepubescent children. In 218 randomly selected 9- to 11-year-old children from nine primary schools CV measures (LV mass, cIMT, LV diastolic function via ultrasound), estimates of body composition (BMI, fat mass [FM] and lean mass [LM] via DXA) and physical fitness data ($\dot{V}O_{2peak}$) were collected. Bivariate correlations and forced entry multiple regression analysis established the relationships and degree of shared variance between predictor and outcome variables. Left ventricular mass was associated ($P < 0.05$) with BMI, LM, FM, systolic blood pressure and $\dot{V}O_2$ and together these explained 58% of the variance in LV mass with LM being the most important predictor ($P < 0.05$). For cIMT significant, but very low, correlations ($r = -0.121$ to 0.389 , $P < 0.05$) were reported with body composition and physical fitness and together these explained only 19% variance in cIMT. Correlations between LV diastolic function and body composition/physical fitness were low (-0.010 to -0.245) with 9% of the variance explained by LM, FM and blood pressure. The lack of a clinically relevant relationship between body composition and physical fitness and both cIMT and LV diastolic function suggests that overweight and unfit young children may not yet be at an increased CV disease risk at this early stage of their development. Thus there is a window of opportunity for intervention programmes to be implemented that reduce CV disease risk before adolescence and adulthood. The correlation of LV mass with body size likely represents normal growth and suggests LV mass data should be interpreted with caution when assessing CV disease risk in children.

A single bout of cold water immersion therapy has no beneficial effect on recovery from the symptoms of exercise induced muscle damage

J. R. Jakeman, R. Macrae, & R. G. Eston

School of Sport and Health Sciences, University of Exeter, Exeter, UK

The purpose of this study was to determine the effectiveness of a single bout of cold water immersion on recovery from exercise-induced muscle damage, a procedure which has become common place in competitive sport. Twenty female participants [age 19.9 ± 0.97 years, height 1.66 ± 0.05 m, mass 63.7 ± 10 kg], all of whom were involved in regular physical activity were recruited for the study.

Participants completed ten sets of ten vertical plyometric jumps in order to induce muscle damage, and then randomly assigned to a control or a treatment group. The treatment group was given a single bout of hydrotherapy in the form of a 10-min cold water immersion at 10°C immediately following plyometric exercise. Indicators of muscle damage were plasma CK activity, perceived soreness and concentric strength of the quadriceps. All indicators were assessed immediately prior to plyometric exercise, and at 1, 24, 48, 72 and 96 h subsequent to plyometric exercise. Data were analysed using a two-factor (group \times time) ANOVA. Although significant main effects for time were observed on perceived soreness ($F_{5,45} = 14.6$, $P < 0.01$ control group values 0.5 ± 0.7 , 1.1 ± 1.1 , 2.4 ± 1.3 , 3.4 ± 2 , 2.4 ± 1.7 , 1.2 ± 0.8 ; treatment group values 0.75 ± 0.7 , 1.7 ± 0.9 , 3.4 ± 1.7 , 2.9 ± 2.4 , 1.7 ± 1.2 , 0.9 ± 1.4), concentric muscle strength ($F_{5,45} = 7$, $P < 0.01$, control group values 149 ± 31 , 136 ± 21 , 136 ± 23 , 133 ± 29 , 143 ± 33 , 154 ± 25 Nm; treatment group values 151 ± 24 , 129 ± 21 , 137 ± 27 , 129 ± 28 , 141 ± 25 , 145 ± 27 Nm), and CK activity ($F_{2,6, 21} = 4.25$, $P < 0.05$, control group values 108 ± 56 , 118 ± 34 , 141 ± 88 , 104 ± 54 , 111 ± 74 , 110 ± 63 IU; treatment group values 123 ± 82 , 163 ± 88 , 182 ± 131 , 124 ± 88 , 109 ± 47 and 130 ± 82 IU for values at baseline, 1, 24, 48, 72 and 96 h, respectively), there were no significant group \times time interaction effects on any of the measured variables. It is therefore concluded that a single bout of cold water immersion after eccentric type exercise had no beneficial effects on the recovery from exercise induced muscle damage.

A comparison of the anthropometric characteristics of amateur club level rowers

S. Jutley¹, S. Taylor², T. Donovan², & S. A. Sparks³

¹*Department of Human and Health Sciences, School of Biosciences, University of Westminster, London, UK,*

²*Department of Sport and Exercise Science, School of Health, Social Care and Sport and Exercise Science,*

North East Wales Institute, Wrexham, UK, and ³*School of Sport, University of Cumbria, Lancaster, UK*

Much of the data published on the physique of rowers is based predominantly on heavyweight rowers. Few studies have compared heavyweights and lightweights despite the need for anthropometric profiles. The purpose of this study was to obtain anthropometric data and somatotype for lightweight and heavyweight amateur club level rowers. Nine heavyweight males, seven lightweight males, thirteen heavyweight females and nine lightweight females

Table I. Summary of anthropometric characteristics of amateur club level rowers.

	Lightweight males	Heavyweight males	Lightweight females	Heavyweight females
Body mass (kg)	74.5 (3.8)*	85.3 (9.3)	58.6 (2.3)	71.4 (7.4)
Height (m)				
Standing	183.0 (5.1)	187.8 (5.0)	169.4 (3.0) ^Δ	175.0 (7.5)
Sitting	94.0 (2.8)	95.5 (3.1)	88.5 (2.5)	90.5 (4.8)
Body fat (%)	10.6 (2.6) ^Δ	15.8 (4.6)	19.2 (1.9)*	24.1 (3.1)
Girths (cm)				
Abdominal	79.6 (3.2) ^δ	93.1 (6.0)	77.1 (4.1)*	85.9 (4.9)
Hip	95.2 (2.0) ^Δ	100.6 (5.5)	91.7 (2.4)*	102.4 (4.7)
Waist	76.4 (3.0) ^δ	84.3 (5.6)	69.0 (2.1)*	74.4 (2.8)
T Upper arm	33.4 (1.3) ^Δ	35.2 (1.5)	27.5 (0.9) ^δ	30.3 (1.7)
Upper thigh	56.7 (2.4)*	61.6 (4.4)	54.8 (1.3) ^δ	61.8 (3.8)
Breadths (cm)				
Femur condyle	9.9 (0.4)	10.2 (0.5)	8.9 (0.2) ^δ	9.6 (0.4)
Biacromial	41.3 (1.1) ^Δ	43.0 (1.4)	37.2 (1.1)	38.4 (2.0)
Somatotype	1.5-4.9-3.2	3.2-4.8-2.7	2.4-3.4-3.3	3.6-4.1-2.3

*Denotes a significant intra-gender difference between heavyweight and lightweight rowers ($P < 0.01$).

^ΔDenotes a significant intra-gender difference between heavyweight and lightweight rowers ($P < 0.05$).

^δDenotes a significant intra-gender difference between heavyweight and lightweight rowers ($P < 0.001$).

took part in this study. Each subject underwent a full anthropometric assessment in accordance with ISAK guidelines (Marfell-Jones, Olds, Stewart, & Carter, 2006: *International standards for anthropometric assessment*. Potchefstroom, South Africa: The International Society for the Advancement of Kinanthropometry). Body fat was ascertained using air displacement plethysmography and somatotype was calculated using the Heath-Carter method (Heath & Carter, 1967: *American Journal of Physical Anthropology* 27:57-74). Data were analysed using one-way ANOVA and Newman-Keuls multiple comparisons with significance accepted at $P < 0.05$. The heavyweight males were significantly heavier ($P < 0.001$), had greater abdominal, hip and waist girths, and greater iliac crest, supraspinale and abdominal skinfolds and total body fat compared with their lightweight counterparts ($P < 0.05$). Stature and sitting height neither differ between the two groups nor were there any differences in limb lengths. The somatotype of the heavyweight males was 3.2-4.8-2.7 compared to 1.5-4.9-3.2 for lightweight males. The heavyweight females had significantly greater femur condyle breadth, hip girth, knee girth, tensed upper arm girth, upper thigh girth, body mass and body fat ($P < 0.001$) than the lightweight females. The heavyweight females were significantly heavier ($P < 0.001$) and taller ($P < 0.05$) than their lightweight counterparts. The somatotypes were 3.6-4.1-2.3 and 2.4-3.4-3.3 for the heavyweight females and lightweight females, respectively. Heavyweight male and lightweight male rowers have similarities in heights and limb lengths, but the differences in physique are reflected in body composition. Heavyweight females rowers are taller and heavier, with

longer forearm lengths than lightweight females. The difference in weight category between the female groups is due to both stature and body composition, but this was not the case in the male weight category rowers. These findings may have implications for talent identification.

Low-back problems in recreational divers using self-contained underwater breathing apparatus: Prevalence and specific risk factors

K. Knaepen^{1,2}, E. Cumps², E. Zinzen¹, & R. Meeusen²

¹Department of Movement Education and Sports Training, Faculty of Physical Education and Physiotherapy, Vrije Universiteit Brussel, Brussels, Belgium and ²Department of Human Physiology & Sports Medicine, Faculty of Physical Education and Physiotherapy, Vrije Universiteit Brussel, Brussels, Belgium

Low-back problems (LBP) are one of the most common musculoskeletal disorders in the general population, with reported lifetime prevalence of 50-80%. Also certain sports (e.g. gymnastics, alpine skiing, running, triathlon) are at risk of LBP and its repercussions. This preliminary epidemiological study was undertaken to examine the lifetime and one-year-prevalence of LBP among recreational Flemish scuba divers and to identify possible, general and sport specific, risk factors associated with the occurrence of LBP.

A retrospective, valid and reliable self-assessment questionnaire was developed to gather data about

demographics, general risk factors of LBP, injuries, properties of scuba diving and prevalence and characteristics of LBP among active scuba divers. A total of 183 recreational scuba divers (men: $n=140$, mean age 40.4 ± 12.7 years; women: $n=43$, mean age 35.0 ± 10.9 years) randomly selected in 10 (inter)nationally recognised scuba diving clubs, participated in the study. Lifetime and 1-year-prevalence of LBP among recreational Flemish scuba divers were respectively, 55.2% and 49.7%. Within the group of scuba divers with LBP, 41.8% reported a, not necessarily causal, relationship between LBP and scuba diving activities. No significant differences in general risk factors for LBP could be found between the groups ($P \geq 0.01$). When considering sport-specific risk factors, scuba divers suffering from LBP generally had a significant higher dive certificate than subjects without LBP ($P=0.007$). Scuba divers with LBP also used significantly more weights on their weight belts during training in swimming pools compared with scuba divers without LBP ($P=0.003$).

In scuba diving, LBP gives reason for moderate concern. Sport-specific risk factors for LBP found in this study are not persuasive. Further (bio-mechanical) research should point out whether or not scuba diving characteristics actually contribute to LBP.

Understanding lower limb function in the maximal instep kick in soccer

A. Lees¹, I. Steward¹, N. Rahnama^{1,2}, & G. Barton¹

¹Research Institute for Sport and Exercise Sciences, Liverpool John Moores University, Liverpool, UK, and

²Faculty of Physical Education and Sport Sciences, Isfahan University, Isfahan, Iran

The maximal instep kick is an important and defining skill of soccer. Past researchers have investigated performance of the maximal instep kick using three dimensional (3D) analyses but no investigator has attempted to explain the observable features in the kicking action in terms of the benefits to performance and risks to players. Observable features of the kicking skill are the angled approach to the kick, an orientation of the body away from the ball at impact, a consistently flexed knee of the support leg during stance, cocking of the kicking leg, and flexion of the kicking leg knee at impact. The aim of this study was, through a comprehensive 3D analysis of lower body function, to identify and explain the benefits and risks of the maximal soccer instep kick.

Ten skilled soccer players (mean \pm s: age 23.4 ± 2.5 years; mass 71.2 ± 6.8 kg; height $1.781 \pm$

0.048 m) performed ten trials of a maximal soccer instep kick during which force (960 Hz) and motion (240 Hz) data were collected. A lower-limb 27 point six degrees of freedom model was used to compute kinematic and kinetic variables over the flight, pre-contact and post-contact phases of the kick.

The mean ball velocity achieved was 25.7 ± 2.4 $\text{m} \cdot \text{s}^{-1}$, range 22.2–28.9 $\text{m} \cdot \text{s}^{-1}$.

For the support leg, the ground reaction force generated as it made contact with the ground was characterised by a wholly lateral medio-lateral (F_x) and a wholly braking anterior-posterior (F_y) force component. The mean peak forces were $F_x = -4.1 \text{ N} \cdot \text{kg}^{-1}$; $F_y = -5.7 \text{ N} \cdot \text{kg}^{-1}$ and $F_z = 14.3 \text{ N} \cdot \text{kg}^{-1}$ which occurred before ball contact. At contact, the knee joint of the support leg flexed by 42° . The joint longitudinal rotational angles suggest that during the pre-contact phase the foot everts (7°) and then inverts (2°) relative to the shank, the shank internally rotates (22°) relative to the thigh, and the thigh externally rotates (7°) and then internally rotates (4°) relative to the pelvis. With regard to the kicking leg, it remained flexed by 57° at contact. The hip joint maintained a steady mean velocity of around $4 \text{ m} \cdot \text{s}^{-1}$ throughout the approach but began to reduce before ball contact. The knee joint showed a characteristic increase in mean velocity reaching a peak of $9.1 \text{ m} \cdot \text{s}^{-1}$, whereas the ankle reach its peak mean velocity of $13.6 \text{ m} \cdot \text{s}^{-1}$ at contact. The foot inverts (3°) and then everts (10°) relative to the shank, the shank externally rotates (8°) in two stages relative to the thigh, and the thigh externally rotates (10°) and then internally rotates (2°) relative to the pelvis. The internal rotation of the shank and eversion of the foot suggests that the kicking foot is being orientated to control the impact with the ball.

With regard to an understanding the skill, a complex sequence of events in the kick was apparent and these were related to both control and performance. Control was achieved by creating dynamic stability – a balancing of the dynamic forces so as to provide a stable platform for ball contact to take place. The angled approach allowed for this while also allowing the body to tilt away from the ball raising the kicking leg. This in turn allowed the knee to reach a greater degree of extension at impact than would otherwise be the case. The flexed kicking leg at impact allowed the knee to clear the ground and to extend through impact with the ball. Two performance enhancing mechanisms were identified, a stretch-shorten cycle of the support leg hip-adductor muscles, and of the kicking leg knee extensors during leg cocking. The hip muscles were found to be major contributors to performance, with some

extra benefit coming from the knee extensors of both the support and kicking legs. Two important injury mechanisms were identified, the stretch-shorten cycle associated with the support leg hip adductors and the internal rotation of the support leg shank relative to the thigh.

The effect of timing of music exposure on performance, perceived exertion and psychological affect during a 10-km cycling time trial

H. Lim¹, G. Atkinson¹, M. Eubank¹, & C. Karageorghis²

¹Research Institute for Sport and Exercise Sciences, Liverpool John Moores University, Liverpool, UK and ²School of Sport and Education, Brunel University, West London, UK

Previous investigators of the psychophysical effects of music on performance (Atkinson, Wilson, & Eubank, 2004: *International Journal of Sports Medicine* 25:611–615) have yet to explore the effects of music when deployed at different times during exercise. The aim of this study was to investigate the effects of music on performance, ratings of perceived exertion (RPE) and affect when introduced and removed at different periods of a 10-km cycling time trial (TT).

Eleven males (mean age = 24.9, $s = 6.1$ years) completed a 10-km TT in three conditions (1) no music, (2) music removed between 5 and 10 km, (3) music introduced between 5 and 10 km. Performance (race time, power, cadence, speed) were measured each km and RPE were assessed at 2.5, 5, 7.5 and 10 km. Positive (PA) and negative affect (NA) were measured at 0.5, 4.5, 5.5 and 9.5 km. Data were analysed with a condition \times distance ANOVA.

No significant main effects of condition were found for performance, RPE and affect ($P > 0.05$). Nevertheless, a significant interaction between condition and distance was found for cycling speed; participants cycling faster at the start of the “music introduced” TT than in both the “no music” and “music removed” TTs ($P = 0.031$). Both music conditions exhibited a significant drop in PA at 5.5 km compared with the constant affect observed in the no music condition (Interaction $P = 0.005$).

These exploratory findings suggest that performance and affect depend on the way music is introduced or removed during exercise. Findings can be explained using the central governor model of fatigue, which emphasises the influence of neural and behavioural mechanisms on pacing strategy.

Skilled perception and cognition in cricket batting

A. McRobert¹, A. M. Williams¹, P. Ward², D. W. Eccles², & K. A. Ericsson²

¹Research Institute for Sport and Exercise Sciences, Liverpool John Moores University, Liverpool, UK and ²Department of Psychology, Florida State University, Florida, USA

Perceptual-cognitive skills are crucial to performance in many domains, such as driving, aviation and sports performance. It is well documented that anticipation is a critical component of expert performance in fastball sports such as cricket and the pick-up of pre-flight information from the bowler's movements is crucial to coordinating a successful response (Williams, Davids, & Williams, 1999: *Visual perception and action in sport*. London: E&FN Spon). At present, few researchers have explored how cognitive knowledge about current situations and past events influences the selection of a response, particularly if the task parameters alter (e.g., spin *vs.* fast). We investigated how advance cue information and conceptual knowledge influences decision-making during a simulated cricket batting task. Skilled ($n = 10$) and less skilled ($n = 10$) participants made movement-based responses to life-size back projected images of bowlers. The test film comprised 36 novel and randomised clips from six fast and four spin bowlers. During the task, outcome measures, eye-movement data and immediate retrospective verbal reports were collected. Skilled batters ($M = 373.2$ mm) were significantly more accurate in their anticipatory judgements than the less skilled ($M = 489.1$ mm) group. Both groups demonstrated greater accuracy when anticipating spin ($M = 414.3$ mm) compared to fast ($M = 444.7$ mm) deliveries. Eye-movement data revealed that less skilled batters spent more time fixating on the ball-hand location ($M = 63.8$ *vs.* mean = 56.2%), whereas skilled batters extracted additional information from central areas of the body such as head-shoulder ($M = 6.7$ *vs.* 12.4%) and trunk-hips ($M = 5.5$ *vs.* 9.5%). Skilled ($M = 5.1$) batters fixated on more locations than their less skilled ($M = 4.2$) counterparts. Further differences were noted in visual behaviour, batters exhibited fixations of longer duration ($M = 339.3$ *vs.* 385.1 ms) and spent more time fixating the ball-hand location when viewing spin ($M = 64\%$) compared with fast ($M = 56\%$) deliveries. In contrast, batters fixated on more central areas of the body when viewing fast, compared to spin deliveries ($M = 20.8$ *vs.* 13.2%). Verbal report data demonstrated a difference in the level of cognitive processing with the

skilled batters making significantly more high order “prediction” ($M=7.3$ vs. 1.5%) and “planning” ($M=12.5$ vs. 4.3%) statements compared to less skilled batters. In conclusion, visual behaviour is constrained by both the task parameters and the skill level of the batter. Skilled batters visually search and encode scenes at a rich and sophisticated level due to the conceptual knowledge from the current situation and previous experience.

Predicting adiposity in children in BMI categories using dual-energy X-ray absorptiometry and the sum of skin-fold measures

N. McWhannell¹, J. Henaghan², L. Foweather¹, L. Graves², D. A. Doran¹, T. Reilly¹, & G. Stratton¹

¹Research Institute of Sport and Exercise Sciences, Liverpool John Moores University, Liverpool, UK

Instead of dual-energy X-ray absorptiometry (DXA), anthropometry is commonly used for adiposity measurement as it is less expensive and more suitable for use in field settings. The number of skin-fold measures used to predict body fat in children varies greatly, which questions the number of skin-fold sites needed to obtain an accurate assessment of whole body fat. The aim of this investigation was to identify the optimal number of skin-fold site measurements necessary to accurately measure body fat as confirmed by DXA in a normal, overweight and obese BMI population.

One hundred and forty-six randomly selected local school children, (girls $n=88$, boys $n=58$) (9.69 ± 0.3 years had body mass index (BMI) calculated (kg/m^2) and classified using gender specific cut-points; normal ($n=76$, girls $n=50$, boys $n=26$), overweight ($n=52$ girls $n=31$, boys $n=21$) and obese ($n=18$ girls $n=7$, boys $n=11$) (Chinn & Rona, 2005: *Annals of Human Biology* 31:695–696). Percent body fat was determined by DXA (Hologic QDR, USA) and skin-fold measures were taken by an ISAK trained researcher from eight sites (triceps, subcapula, biceps, iliac crest, supraspinale, abdomen, front thigh and medial calf). The sum of 8, 7(excl. iliac crest) and 4 (triceps, subcapula, supraspinale and medial calf) skin-fold sites were recorded. Forced-entry multiple regression analysis established the relationship between the number of skin-folds and percent body fat for each BMI category as defined by the DXA.

In the normal category, the regression model accounted for 76% (adjusted $R^2=0.76$) of variance ($F=79.7$, $P<0.01$). The sum of 8 ($\Sigma 8$) skin-fold sites was the best predictor of percent body fat ($\beta=1.58$, $P<0.01$). In overweight children, the regression model accounted for 77.5% of variance ($F=59.5$, $P<0.01$).

The $\Sigma 7$ skin-fold sites significantly was found to predict percent body fat determined by DXA ($\beta=1.23$, $P<0.01$). In obese children, the regression model accounted for 60.0% of variance ($F=9.8$, $P<0.01$). The best predictor of body fat was $\Sigma 4$ skin-fold sites ($\beta=1.03$, $P=0.01$); there was no additional contribution to the total variance explained by the $\Sigma 7$ ($P=0.75$) or $\Sigma 8$ ($P=0.30$) skin-fold sites.

The number of skin-fold assessments required to predict percent body fat is BMI dependent. The number of required site assessments reduces as BMI increases. Four sites are the most predictive for the obese category, seven for the overweight and eight for the normal. This result indicates a smaller number of skin-fold sites may be acceptable on overweight and obese children. This may have the additional benefit of minimising discomfort, invasiveness and assessment time.

Central fatigue – the serotonin hypothesis and beyond

R. Meeusen

Department of Human Physiology & Sportsmedicine, Faculty of Physical Education and Physiotherapy, Vrije Universiteit Brussel, Brussels, Belgium

Fatigue can be defined as a failure to maintain the required or expected force or power output during a long duration exercise. However, local muscle fatigue can develop even after a short duration exercise or occupational task even before local metabolism or neuromuscular functioning is impaired. This led to the hypothesis that there exists a “supra-spinal” or central fatigue. The original “central fatigue hypothesis” suggested that an exercise-induced increase in extracellular serotonin (5-HT) concentrations in several brain regions contributed to the development of fatigue during prolonged exercise. Serotonin has been linked to fatigue because of its well-known effects on sleep, lethargy and drowsiness and loss of motivation. Several nutritional and pharmacological studies have attempted to manipulate central serotonergic activity during exercise, but this work has yet to provide robust evidence for a significant role of 5-HT in the fatigue process. However, it is important to note that brain function is not determined by a single neurotransmitter system and the interaction between brain 5-HT and dopamine (DA) during prolonged exercise has also been explored as having a regulative role in the development of fatigue. Convincing evidence for a role of dopamine in the development of fatigue comes from work investigating the physiological responses to amphetamine use, but other strategies to manipulate central catecholamines

have yet to influence exercise capacity during exercise in temperate conditions. Recent findings have, however, provided support for a significant role of dopamine and noradrenaline in performance during exercise in the heat (Meeusen et al., *Sports Medicine* 36(10):881–909). As serotonergic and catecholaminergic projections innervate areas of the hypothalamus, the thermoregulatory centre, a change in the activity of these neurons may be expected to contribute to the control of body temperature whilst at rest and during exercise. Fatigue during prolonged exercise clearly is influenced by a complex interaction between peripheral and central factors.

Salivary cortisol and alpha-amylase of Italian firefighters during a simulated task

F. Perroni¹, A. Tessitore¹, L. Cignitti¹, C. Cortis², E. D'Artibale¹, C. Lupo¹, M. De Rosas³, G. Cibelli³, & L. Capranica¹

¹Department of Human Movement and Sport Sciences, IUSM of Rome, Italy, ²Department of Health Sciences, University of Molise, Campobasso, Italy, and ³Department of Biomedical Sciences, University of Foggia, Italy

Firefighting is a physically demanding and hazardous occupation (Gledhill & Jamnik, 1992: *Canadian Journal of Sports Science* 17:207–213), implying variable and unpredictable working conditions (Bos, Mol, Visser, & Frings-Dresen, 2004: *Ergonomics* 47:446–460). The aim of this study was to evaluate the effect of a simulated firefighting intervention on salivary alpha-amylase (A-A) and free cortisol (C) levels, which reflect the sympathetic nervous system and hypothalamic-pituitary-adrenal axis reactivity to stressful situations, respectively (Kivlighan & Granger, 2006: *Psychoneuroendocrinology* 31:703–714).

Oxygen consumption ($\dot{V}O_2$), heart rate (HR), blood lactate (La) and rating of perceived exertion (RPE) were monitored in nine male fire-fighters (age: 30.5 ± 5.5 years; BMI: 24.9 ± 2.8 ; $\dot{V}O_{2\max}$: 52.2 ± 7.4 ml · kg⁻¹ · min⁻¹) while climbing a firemen's ladder, descending a 4-story building carrying 20 kg, running 250 m to a smoke chamber with circuit in the dark, and running 250 m to finish line. Analysis of variance for repeated measures ($P < 0.05$) was applied to salivary values (A-A: kinetic reaction assay; C: ELISA method) sampled before the task, and at 30 min and 90 min of the recovery period.

During the 12-min task 300 ± 46 ml · kg⁻¹ · min⁻¹, 164 ± 8 beat · min⁻¹ ($81 \pm 28\%$ HR_{max}), 9.6 ± 3.4 mM, and 17 ± 1 pt (“very hard”) values were recorded for, $\dot{V}O_2$, HR, La, and RPE, respectively. Peak values for A-A (279.83 ± 66.93 U · ml⁻¹)

and cortisol (30.46 ± 3.63 nmol · l) were found at 30 min of post-test recovery, with an increase of 43 and 27% from pre-test, respectively. At 90 min of the recovery, A-A (145.66 ± 38.70 U · ml⁻¹) and C (13.92 ± 3.78 nmol · l) values were lower than pre-test ones (A-A: 195.50 ± 95.65 U · ml⁻¹; C: 24.00 ± 5.32 nmol · l). A significant difference emerged only between pre-test and 30-min post-test C. A significant correlation ($r = 0.74$; $P < 0.05$) was found between A-A and La peak values only.

This preliminary study showed that the simulated task imposed an intense stress on firefighters, eliciting a significant rise in post-intervention cortisol. The lack of significant A-A increases might be due to the quicker reaction of salivary alpha-amylase to stress (Gordis, Granger, Susman, & Trickett, 2006: *Psychoneuroendocrinology* 31:976–987) so that its peaks were missed. Further research is needed during real firefighting where high emotional stress might also be present.

The effects of the zone-diet on training measures in recreational master athletes

M. F. Piacentini^{1,2}, G. Salvatori³, C. Di Cesare³, P. Filomena³, M. Olivi¹, R. Meeusen², & L. Capranica¹

¹Department of Human Movement and Sport Sciences University Institute for Movement Science, Rome, Italy, ²Department of Health Science University of Molise, Campobasso, Italy, and ³Department of Human Physiology and Sportsmedicine, Vrije Universiteit Brussel, Belgium

Master athletes do not have comparable technical support of elite athletes and often adopt “word-of-mouth” training and nutritional programmes to optimise their performance. The zone-diet (40% carbohydrate, 30% protein and 30% fat), claiming to improve performance, reduce body fat and increase muscle mass (Sears, 2000: *Sports Medicine* 29:289–294), might attract recreational athletes. Previous studies showed no positive effects on endurance performances and reported high drop-outs during the experiments because unable to train as usual (Jarvis, McNaughton, Seddon, & Thompson, 2002: *Journal of Strength and Conditioning Research* 16:50–57; Piacentini, Parisi, Bonanni, & Capranica, 2004: *9th Annual Congress of the European College of Sport Science*, 2007; *12th Annual Congress of the European College of Sport Science*). Therefore, the aim of this study was to evaluate the effects of a 2-week zone-diet period on performance and training parameters of endurance runners.

Six master athletes (52 ± 4 years, 74 ± 6 kg, and 52 ± 3 ml · kg⁻¹ · min⁻¹) filled in a 1-week food record and wore a sensor (Sensewear ARMBAND)

that continuously gathered data (i.e. movement, heat flux, skin temperature, galvanic skin response) in order to design an iso-caloric zone-diet regimen, maintaining the protein-to-carbohydrate ratio within the required range of 0.60–0.75. Before (Pre) and after (Post) 15 days on the zone-diet, athletes performed two exercise tests to exhaustion with a 3-h interval. During the 4-week prior and the 2-week zone-diet period subjects filled a daily online training diary (BLITS[®]) and a POMS questionnaire for objective and subjective evaluations of training. Analysis of variance ($P < 0.05$) for repeated measures was applied for pre–post differences.

Significant decreases in body mass (Pre: 73 ± 5 , Post: 69 ± 5 kg), body fat (Pre: 10 ± 2 , Post: 9 ± 2 kg) and free fat mass (Pre: 63 ± 6 , Post: 60 ± 6 kg) were observed, while running performances showed no significant difference with the experimental treatment. During the 2-week on the zone-diet athletes reported a 26 and 8% increase in their perception of training intensity and monotony respectively. The POMS showed an increase in fatigue and depression scores with a decrease in vigour. One athlete dropped out of the study after 10 days on the zone-diet.

The results of the present study do not support an enhancement in performance or an increase in FFM determined by the zone diet, confirming previous work. Because of its low carbohydrate content it cannot be recommended as a nutritional regimen for elite and recreational runners because training sessions might be compromised.

***In vitro* soft tissue data acquisition quality control of the dual-energy X-ray absorptiometry**

S. Probyn¹, J. Wallace², J. P. Clarys¹, & T. Reilly²

¹*Experimental Anatomy, Vrije Universiteit Brussel, Brussels, Belgium and* ²*Research Institute for Sport and Exercise Sciences Liverpool John Moores University, Liverpool, UK*

The acquisition of quantities of fat (chemical) or adipose tissue (morphological) is essential for the determination of a nutrition status and its associated health risks. Soft tissue measurements including lean mass and its densities are desirable also in various clinical research and public health settings. This has led to a proliferation of techniques and equipment for the *in vivo* determination of body composition. The stark fact remains that except for the anthropometric skinfold assessment (Clarys, Martin, & Drinkwater, 1987: *Journal of Sports Sciences* 5:3–33; Clarys, Probyn, & Marfell-Jones, 2005: *Ergonomics*

48(11–14):1445–1461) none of the indirect *in-vivo* approaches to estimate body adipose tissue has been validated against direct cadaver or carcas dissection data.

Since the development of dual energy x-ray absorptiometry or DXA (Mazess, Peppler, Chesnut, Nelp, Cohn, & Zanzi, 1981: *Calcified Tissue International* 33:361–363) as a tool for the measurement of bone density and mineral content for the detection of osteoporosis, it obtained not only a status of criterion method, but also became a tool for the measuring regional and whole body masses, lean tissue and fat. A number of validation and quality control attempts have been made, but mostly against other indirect *in-vivo* techniques and some against direct chemical analysis indicating important difference of the coefficient of variance.

The purpose of this study was to conduct an *in vitro* validation and/or quality control of the morphological soft-tissue data acquisition of DXA using porcine hind legs dissection as the criterion method. Fourteen hind legs were scanned with DXA using the *ad hoc* software (Hologic QDR for windows XP version 12.4.3) weighed in air and water and dissected into its major tissues (e.g. skin, adipose tissue, muscle and bone), again weighed in air and water for density purposes. All data were normally distributed. Means and standard deviations for all variables were calculated with SPSS for windows version 12.0.2 including paired students *t*-test and Pearson's correlation coefficients. Technical error of the measurement and coefficient of variation were calculated to quantify systematic bias and random error.

The results show systematically high to excellent correlations between DXA and dissection data acquisition ($r^2 = 0.75–0.99$) but the absolute indirect DXA and the direct dissection values are for all values significantly different at a $P < 0.05$ level. The DXA method significantly overestimated total weight, lean mass and fat free mass and underestimated both mass and % adipose tissue.

This study has not measured (via ashing) the bone mineral content (BMC), which explains the very different values of BMC and bone mass. However the different but corresponding value levels suggest serious doubts on the claimed chemical accuracy of DXA data acquisition. These results indicate clearly that DXA correlates more closely with morphological values than with chemical values as claimed by the manufacturer.

This “pilot” study suggests also that a “simple” combination of skin, adipose tissue, muscle and bone may give an incomplete picture of reality as one needs to measure viscera, heart, lungs, brain, connective tissue, air pockets, ... etc of the body also. Repeating this validation and quality control study with intact (e.g. complete) bodies is advised.

Incidence, type and mechanism of injuries in Iranian professional judokas

N. Rahnama, E. Bambaiechi, & H. Reza Sadeghipour

Faculty of Physical Education & Sports Sciences, Isfahan University, Isfahan, Iran

The aim was to investigate injury rate, type and mechanism of injuries in Iranian professional judokas.

Thirty-two subjects from the national professional players were studied. A dedicated questionnaire was used for the study and chi-squared tests were used to analysis of data.

During the past year 314 (981.2/100) injuries were reported by athletes. Injuries in right-guard athletes (53.6%) were higher than for left-guard (46.4%) but this differences was not significant ($\chi^2 = 1.5, P = 0.21$). Results showed that injuries in training (57.3%) were significantly higher than at other time ($\chi^2 = 135, P < 0.001$). Also the proportion of minor injuries (37.8%) were higher than for moderate (30.2%) or severe injuries (31.8%), but this difference was not significant ($\chi^2 = 3.06, P = 0.21$). The lower limb (44.5%) was the primary area of injury ($\chi^2 = 173.4, P = 0.000$) and the knee joint (21%) was reported as being the region most injured ($\chi^2 = 185.7, P = 0.000$). Dislocations (25.5%), sprains (22.9%) and fractures (14.3%) accounted for most injuries in judokas and the difference between types of injuries was significant ($\chi^2 = 36.1, P < 0.001$). Fatigue (31.3%) was the main mechanism of injuries ($\chi^2 = 10.2, P = 0.03$). Of all injuries, 56% was in prefer of judo players and 44% in non-prefer, and this difference was significant ($\chi^2 = 4.5, P = 0.03$).

The incidence of injury in Iranian judokas was extremely high. Professional judo players are exposed to a high risk of injury and there is a need to investigate factors contributing to the pattern of injuries especially in training and find ways of reducing this risk.

Reliability and validity of the system for observing children's activity and relationships during play

N. D. Ridgers^{1,2}, G. Stratton^{1,2}, & T. L. McKenzie³

¹REACH (Research into Exercise, Activity and Child Health) Group, Liverpool John Moores University, Liverpool, UK, ²Research Institute for Sport and Exercise Sciences, Liverpool John Moores University, Liverpool, UK, and ³School of Exercise and Nutritional Sciences, San Diego State University, San Diego, CA, USA

Children frequently engage in diverse activities and behaviours that are broadly defined as play. Play is the most natural way for children to be active, yet a

number of factors may influence children's physical activity in play contexts. Currently, observation systems to assess physical activity, behaviour and relationships simultaneously during play do not exist.

The aim of the study was to establish the reliability and field validity of the newly developed System for Observing Children's Activity and Relationships during Play (SOCARP).

The SOCARP observation system utilises momentary time sampling techniques to record children's physical activity levels, social group sizes, play activities and social behaviour simultaneously during play. Following the development of the SOCARP, a trained individual observed 60 children (43% male, mean age = 10.41 ± 0.3 years) from seven Liverpool primary schools during school playtimes (16 morning, 41 Lunch, 3 afternoon). Observations took place across 18 days, with 6 days videotaped for reliability purposes. A trained observer subsequently watched and recorded the videotapes on two occasions, at least one week apart, to determine intra-observer reliability. To establish field validity, children also wore a uni-axial accelerometer (GT1M Actigraph) during the observation periods.

Intra-observer agreement scores for the assessed variables were 87% for activity level, 85% for group size, 93% for activity type and 87% for interactions. Pearson's correlations revealed a significant positive correlation between observed SOCARP average physical activity levels (3.73 ± 0.4) and mean accelerometer counts (157.86 ± 72.1; $r = 0.68, P < 0.001$).

The SOCARP observation system can be used reliably by a trained observer to collect data on physical activity levels, group size, play activities and social behaviours in a playtime contexts. Furthermore, the field validity of the activity codes has been further established using an objective physical activity monitor. Although there is a need for inter-observer reliabilities to be established, results suggest SOCARP can be used to detail children's activity and important social and behavioural variables during playtime.

Effects of regular physical activity on the biological rhythms in night shift workers

B. Sesboué¹, B. Mauvieux¹, & D. Davenne²

¹IRMS CHU Côte de Nacre 14033 CAEN Cedex, France and ²CRAPS UFR STAPS Campus II 14032 CAEN Cedex, France

Night work induces degradation and desynchronisation of biological rhythms. Can physical training help to maintain better rhythms and, by this means, provide a better tolerance for night work?

Sixteen night workers volunteered for this study. They were divided in active group (group A, $n = 8$; 43.3 ± 10.3 years, 10 years of aerobic physical activity, three times a week) and sedentary group ($n = 8$, 44.7 ± 7.9 years, no physical activity for at least 10 years). We studied during nine consecutive days: oral temperature, heart frequency during sleep, actimetry, blood pressure, selective attention, spontaneous motor tempo (SMT), peak-flow, muscular force in the dominant hand and in the non-dominant hand, maximal anaerobic alactic power and flexibility.

In the sedentary group, biological rhythms were desynchronised (periods equal 12–26.5 h). In the active group, subjects retained more homogeneous rhythms (period: 23.4–27.1 h), around 24 h. For instance, the temperature had a period of 16.1 h for sedentary group and of 24.1 h. for active group ($P < 0.05$): so the sleep was of poor quality in sedentary group because the rhythm of the temperature was no larger in phase with the waking/sleeping rhythm. The amplitudes were more important within active group than in sedentary group (for instance, the amplitude for temperature was of 0.07°C vs. 0.23°C for active group; $P < 0.05$); so that rhythms were more resistant to desynchronisation and the sleep remained well structured. During the week-end, there was a rapid resynchronisation in the sedentary group because of the social synchronisers.

This study confirms that physical activity can be considered as an additional *zeitgeber* (synchroniser) and can reduce the desynchronisation of rhythms. Exercise is a possible alternative to drugs and phototherapy to improve the tolerance to night-work, especially during aging.

Behaviour and motion analysis of bodily communication in volleyball

M. Sibilio¹, G. Raiola¹, N. Carlomagno²,
M. Galdieri¹, & F. D'Elia¹

¹Department of Science Education, University of Salerno, Salerno, Italy, and ²Faculty of Education, University Suor Orsola Benincasa, Napoli, Italy

Research on the methodology of the training of team sports is frequently focused on the functional aspects, on the conditional abilities, on energy mechanisms and on the bio-mechanical aspects, which often undervalue the function of gestures, signs and mimicking. A more detailed analysis of the diverse actions connected to the phases of a game (sport) can provide evidence for the strategic role of body language and its conditioning ability on performance and results. The cause of this conditioning probably draws on two interdependent traditions of research: the first on the form of non-

verbal communication in team sports, and the second, on the neurobiological mechanisms that connect action and cognition.

Volleyball is a very fast team sport with a very narrow game space (81 square meters per team) whose technical characteristics, tactics and logistics constantly favour non-verbal communication between the players on the court. In particular, the decoding of signs or of mimicking is “functional” when it refers to the same team and when communication between the players is involved or that between the trainer and the athletes on the tactical intentions, strategies and the problems of the game.

Decoding can be “diagnostic” when it is possible to analyse the diverse forms of non-verbal communication of the opposing team, the signs of the athletes and of the trainer, who anticipate or solicit actions of the game. The third form of decoding is “tactics” when the gesture or the action simulates a game intention to solicit a reaction of the adversary who helps his/her own team.

During recent years at the professional level, many trainers have dedicated space to these aspects of non-verbal communication, to their codes and to their technical-tactical uses of gesture, but often undervaluing the scientific aspects that subtend body language.

The present research has the objective to define the first inventory of these signs more frequently used in volleyball, according to:

(i) The principles of corporeal communication based on the theoretical model of Dr. Michael Argyle, Professor of Social Psychology at Oxford University and Fellow of the Wolfson College for his work published in the book *Bodily communication* (1988, pp. 199–209. London: Routledge).

(ii) The aspects of perceptive senses according to the research of Dr. Alain Berthoz (Alain Berthoz is a Psychologist and Neurophysiologist at the “Collège de France” where he is the Director of the Cognitive Physiology Laboratory) published in the book *Le sens du mouvement* (1997, pp. 1–41. Paris: Odile Jacob).

(iii) The neurobiological implications based on the finding of the research about mirror neuron of Giacomo Rizzolatti (Giacomo Rizzolatti is the Director of the Neuroscience Department at the University of Parma (Italy)) published in the book *So quel che fai* (2006, pp. 113–135. Milan: Raffaello Cortina Editore).

The methodology is that of empirical research conducted that will be conducted with a female volleyball team affiliated with the Italian “Championship C Series” during the 2007–2008 seasons. The research began from the observation of the games’ signs (gestures), from its analysis in significant terms, the possible factors of conditioning, and their effect

and relationship on the various defined theoretical aspects.

The research consisted of a phase of observation and of taking pictures and videos of the actions of the game. At the end of the Championship, the pictures and videos were reviewed by the 12 athletes, the trainer and by an outside expert of the team. Using the methodology of a “focus group”, they investigated the influence of the non-performing factors, such as the non-verbal communication in the actions of the game and on the overall agonistic result. (In a game, how many points have been scored by non-verbal strategies? In a Championship, which is the influence of this communicative strategy on the overall agonistic result?).

Sport and disability in Italy – methodological approaches and organisational models

N. Carlomagno¹, G. M. Galdieri², F. D’Elia², P. Mango³, F. Corona¹, & M. Sibilio²

¹Faculty of Education, University Suor Orsola Benincasa, Napoli, Italy, ²Department of Science Education, University of Salerno, Salerno, Italy, and ³Regional Director, Special Olympic Committee, Campania, Italy

In the last year, scientific research, with the support of neuroscience, has provided a cultural contribution to the integration of disabled persons, giving rise to an important evolution of the individual and collective behaviours, enabling stronger achievement of individual autonomy. Recently, the relation between sports and the development of a person has been clearly explained. By analysing the complexity of the cognitive mechanisms and their possible connection with physical movements, it has been determined, based on the finding of the research about mirror neurons by the Italian neurobiologist, Giacomo Rizzolatti (Giacomo Rizzolatti is the Director of the Neuroscience Department at the “University of Parma” (Italy)), “each process of motor control implies an advanced mechanism, and consequently, causes a correlation between a certain neural activity and the possible effects that it can cause” (Rizzolatti & Sinigaglia, 2006: *So quell che fai. Il cervello che agisce e i neuroni specchio*, p. 98. Milano: Raffaello Cortina Editore). The results of this research on disabilities have demonstrated the potentialities of the vicarious senses and the different motor abilities that each person possesses. The theory of multiple intelligences by the American Psychologist, Howard Gardner, demonstrates that “there is the logical ability to plan a good strategy, the ability to recognise familiar space schemes and to then use them immediately” (Gardner, 1983: *Frames of mind*,

the theory of multiple intelligences, p. 252. New York: Basic Books). Even if there is a deficit, a person can practice sports in different ways, confirming the right and the real possibility for a handicapped person to practice sport, both in educational institutions and in out-of-school circumstances.

In 2000, the Italian Ministry of State Education, charged the National Institute of Statistics, to build a national database of persons with a disability. Previously, in 1999, this institute identified the presence of about two million eight hundred thousand (2,800,000) persons with a handicap, of which, about one million of them with an intellectual disability, equal to about 5% of the population. During the 2005–2006 school year, scholastic data from the Italian Ministry of State Education, indicated the presence of 178,220 disabled students from the ages of 3 to 20 years, of which, 21,000 of these persons reside in the Campania region (*La scuola in cifre, Dati Ministero della Pubblica Istruzione Italiana, ROMA 2006*).

Nowadays, in the Italian School, the ones who teach sports to disabled persons are the gym teachers and special teachers for the disabled. In the out-of-school circuit, there are two great organisations: the “Italian Paralympics Committee” and the “Special Olympics Italia”, which respectively, have been recognised by the Italian National Olympics Committee as a “Sports League”. This league coordinates all types of sports for physically disabled persons, and the “Meritorious Association”, which takes care of all the persons with intellectual disabilities.

This work was propositioned by the University of Study of Salerno and its purpose was to build a scientific and organisational model shared by the University, the Italian Paralympics Committee, and the Special Olympic Committee of Italy, for the creation of a network of sports services to support persons with disabilities in the Campania region.

Methodological considerations for determining metatarsophalangeal joint kinetics during sprinting

G. Smith¹ & M. Lake²

¹Department of Sport and Exercise Sciences, University of Chester, Chester, UK and ²RISES, Liverpool John Moores University, Liverpool, UK

The importance of the metatarsophalangeal joint (MPJ) in sprinting has been highlighted by Stefanyshyn and Nigg (1997: *Journal of Biomechanics*, 30:1081–1085). High-speed video observations suggest that current typical measurement procedures (data sampling rate and filtering) might lead to underestimation of segmental derivatives used for

Table I. Mean energy absorbed and generated (J) at the MPJ during shod and barefoot sprinting.

	200 Hz, 8 Hz fc	500 Hz, 30 Hz fc	1000 Hz, 100 Hz fc
Absorbed shod	40.9 ± 3.8	50.6 ± 11.5	57.8 ± 4.6
Generated shod	3.3 ± 1.2	4.9 ± 1.2	5.2 ± 0.7
Absorbed barefoot	56.9 ± 5.6	72.1 ± 3.0	72.0 ± 1.3
Generated barefoot	5.6 ± 2.5	8.0 ± 0.8	7.5 ± 0.1

joint kinetic calculations. The aim of this study was to examine the influence of sampling rate (SR) and filter cut-off frequency (FC) on MPJ kinetics during shod and barefoot sprinting.

A trained, female sprinter performed barefoot and shod sprints along a 30 m indoor runway, contacting a force platform in the middle (Kistler, Switzerland, sampling at 2000 Hz). Kinematic data were captured simultaneously at 1000 Hz, using eight opto-electronic cameras (Qualysis Inc., Sweden). Data were also resampled at 500 and 200 Hz and filtered using a standard, 4th order Butterworth filter with 8, 30 and 100 Hz FCs.

Similar to previous research, the MPJ was a large energy absorber but generated some energy at push-off. Increasing SR and FC, especially in the shod condition, resulted in substantial increases in energy absorbed and generated compared to a typical processing approach (200 Hz SR and 8 Hz FC) (see Table I).

The largest changes in kinetic data occurred between 8 and 30 Hz FC which suggests that high frequency components in that range are important and mostly omitted in the literature. These data indicate that sprint shoes reduce energy dissipated in stance but also limit energy production at take-off and this finding will be confirmed with data on a group of sprinters.

Axillary artery changes in normals during diagnostic arm positioning for vascular compression

C. Stapleton, L. Herrington, & K. George

*Research Institute of Sport and Exercise Science,
Liverpool John Moores University, Liverpool, UK*

To determine changes in axillary artery diameter (D) and peak systolic flow velocity (PSV) in asymptomatic, healthy individuals during upper limb positioning commonly used to assess upper limb vascular pathology in athletes particularly in overhead sports. After subjective and objective screening for individuals with past or present neurovascular compression syndromes, 31 subjects (21 female, 10 male; mean age (s): 25 years (4)), were included in the

study. Subjects were seated with the right arm passively supported. A series of 12 randomised arm positions, incorporating varying degrees of abduction, external rotation and horizontal flexion/extension, were maintained for 30 s before sonographic evaluation. Axillary artery diameter and PSV measured with B-mode and Doppler ultrasound, respectively, and radial systolic blood pressure (BP) and symptom production were recorded for each arm position. The majority of arm positions revealed no change in D or PSV. However, at the extreme of abduction and arm positions incorporating 120° abduction significant ($P < 0.0005$) reductions in axillary artery D and BP were noted. For example, at 120° abduction, mean ($\pm 95\%$ CI) diameter and mean systolic BP was 3.6 mm (0.3) and 93 mmHg (5) compared to 4.2 mm (0.2) and 120 mmHg (4) at baseline. Significant increases in PSV were identified for 120° abduction ($P = 0.001$, median and IQR: 99 $\text{cm} \cdot \text{s}^{-1}$, 84–118) and 120° abduction with 30° horizontal extension ($P < 0.0005$, 94 $\text{cm} \cdot \text{s}^{-1}$, 81–121) compared to baseline (77 $\text{cm} \cdot \text{s}^{-1}$, 64–92). All mean results masked wide heterogeneity illustrated by undetectable BP for 16%, and symptom production for 52% of subjects. The number of individual “positive” responses to extreme arm positions questions the specificity of individual diagnostic tests, such as the hyperabduction manoeuvre. This problem highlights the need to integrate information from the subjective history, clinical presentation, physical examination and imaging results into the diagnostic process.

Physical activity measurement in children

G. Stratton

*Research Institute for Sport and Exercise Sciences,
Liverpool John Moores University, Liverpool, UK*

Physical activity is a relatively new area of study in health science. This is much to do with the burgeoning growth in scientific evidence linking physical activity and fitness to morbidity and mortality in adults. The significant challenge to exercise scientists is the quantification of physical activity. There are over 30 different methods of measuring physical activity, none of which is considered to be the gold standard. Tools such as questionnaires, heart rate monitors, movement counters, observation, doubly labelled water and combinations of these have been used to provide data in health related exercise investigations. Physical activity is a multi-dimensional behaviour and measurement tools are selected depending on the nature of the research question. Unfortunately no single method provides information on the frequency, intensity, time and

type of activity. Children are also a special case as their intermittent and spontaneous patterns of activity are very different to older age groups. Moreover monitors should not be intrusive, yet true activity patterns need to be quantified across full weeks and times of the year. Recent approaches with children have relied on objective methods of measurement and debates have arisen on sampling frequency, in terms of epoch length and wear time. Furthermore, management and analysis of data has been the centre of significant debate where approaches to detecting light, moderate and vigorous activity thresholds in group or individual datasets, as well as the management of missing data remain inconsistent within the field. This presentation will highlight these key issues in physical activity measurement using children and young people as the population of concern.

Body composition of international- and club-level professional soccer players measured by dual-energy X-ray absorptiometry

L. Sutton, J. Wallace, M. Scott, & T. Reilly

Research Institute for Sport and Exercise Sciences, Liverpool John Moores University, Liverpool, UK

Body composition is a key aspect of preparation for soccer; surplus body fat acts as a dead weight during locomotion and bone density is relevant for physical contact (Reilly, 1996: In *Science and soccer*, edited by T. Reilly, pp. 25–47. London: E&FN Spon). The present aim was to determine whether there are differences in body composition between international and non-international professional soccer players playing at the same club level.

Participants included 23 footballers playing for English Premier League clubs but not a national team, and 31 Premier League players who together represented 12 different countries. Each participant underwent a whole-body fan-beam DXA scan (Hologic, Bedford, MA) measuring bone mineral density (BMD), fat mass and residual lean tissue. Scan data were broken down into upper- and lower-body analyses, grouped according to “pre-season” and “competitive season”. Scans were further compared against an age-matched reference group ($n=24$) comprising sedentary male participants. Data were analysed using discriminant function analysis and one-way ANOVA.

For all measured variables, both pre-season and in-season, significant differences ($P \leq 0.05$) were evident between both the international soccer players (Int) and the reference group (Ref), and between the non-international soccer players (Club) and the reference group. The soccer players demonstrated

greater BMD (pre-season: Int 1.380 ± 0.087 , Club 1.399 ± 0.096 ; competitive season: Int 1.394 ± 0.108 , Club 1.381 ± 0.112 ; Ref $1.189 \pm 0.091 \text{ g} \cdot \text{cm}^{-2}$), lower fat mass (pre-season: Int 8.5 ± 1.9 , Club 8.6 ± 2.1 ; competitive season: Int 7.8 ± 1.5 , Club 8.0 ± 2.0 ; Ref $14.4 \pm 5.2 \text{ kg}$) and corresponding percent body fat (pre-season: Int 10.9 ± 2.2 , Club 10.8 ± 2.1 ; competitive season: Int 9.8 ± 1.8 , Club 10.3 ± 1.9 ; Ref $17.3 \pm 3.9 \%$), and greater lean mass (pre-season: Int 65.9 ± 5.1 , Club 67.6 ± 6.9 ; competitive season: Int 68.3 ± 4.4 , Club 66.2 ± 6.2 ; Ref $60.9 \pm 7.6 \text{ kg}$). This pattern remained unchanged when the upper-body and lower-body were examined separately. There were no significant differences between the international and non-international soccer players in any of the compartments of body composition ($P > 0.05$). Bone mineral density and percent fat are the variables best able to discriminate between professional soccer and reference groups.

Professional soccer players are distinct from reference subjects in whole-body and regional bone density and soft tissue composition. Body composition analysis could not discriminate between international and non-international elite professionals.

The attraction of cross-country running

L. Sutton, N. Chester, & T. Reilly

Research Institute for Sport and Exercise Sciences, Liverpool John Moores University, Liverpool, UK

Recreational and competitive running events are held on road, synthetic tracks, parkland and on more rugged off-road terrain (Creagh et al., 1998: *Ergonomics* 41:1029–1033). Over the last few decades, road running has prospered; there has not been a concomitant rise in cross-country running for improving health and fitness. The aim was to establish motives, practices and preferences of runners participating on both terrains.

The survey involved 60 male (age 38.8 ± 13.6) and 31 female (age 30.8 ± 12.0) runners, ranging from recreational to national competitors. Respondents' current weekly training distance averaged $45.8 \pm 27.5 \text{ km}$, and was $72.8 \pm 39.8 \text{ km}$ when at peak fitness (mean $\pm s$). Questionnaires required participants to rank set responses in order of importance or rate their agreement with a given statement on a Likert-type scale ranging from 10 (strongly agree) to 0 (strongly disagree). Data were analysed using χ^2 , t -test, Spearman's rho, Mann–Whitney U , and ANOVA.

The cross-country running distance covered per week increased with competitive level (recreational $5.4 \pm 5.6 \text{ km}$; competitive $15.4 \pm 15.5 \text{ km}$; $P < 0.001$). Cardiovascular fitness was most frequently

cited (41%) as the most important reason for running. Cross-country running was believed to provide a greater cardiovascular workout than road running (cross-country 8.8 ± 1.3 ; road 8.3 ± 1.5 ; $P < 0.001$). "Beauty of the countryside" was considered the main motive for running cross-country (8.1 ± 2.0) followed by "improved air quality" (8.0 ± 2.1). While there were no significant differences between sexes, appreciation of these environmental factors increased progressively with age ("beauty" $r_s = -0.238$; "air quality" $r_s = -0.363$; $P < 0.05$). Cross-country running was believed to provide a greater psychological high (cross-country 8.0 ± 1.7 ; road 7.6 ± 1.7 ; $P < 0.001$), and result in fewer training-related injuries than road running (cross-country 6.5 ± 2.4 ; road 5.7 ± 2.7 ; $P < 0.001$). Other benefits of cross-country running included feelings of safety and solitude.

Results indicate that runners view cross-country running as physiologically and psychologically beneficial. Advantages highlighted centred on exposure to the natural environment, surface compliance and relative safety. In terms of health-promotion benefits, cross-country running was preferred to road running for subjective and preventative reasons, despite the greater promotion of road running for recreation.

An analysis of the time duration of ground strokes in Grand Slam men's singles tennis using the computerised scorebook for tennis

H. Takahashi, T. Wada, A. Maeda, M. Kodama, & H. Nishizono

National Institute of Fitness and Sports in Kanoya, 1 Shiromizu-cho, Kanoya City, Kagoshima, Japan

The authors developed a computerised scorebook for tennis that can record the time factors of tennis matches (Takahashi et al., 2006: *International Journal of Performance Analysis in Sport* 6(2):15–25; Takahashi et al., 2007: *Proceedings of the International Symposium on Computer Science in Sports*: 300–304.). The scorebook records the time factor at 1/100 intervals by using the computer's internal clock. We click the record button at the same time of the player's impact and the scorebook records the clock time as a time data. The time duration of each shot was defined as the time difference between one shot and the previous shot. The time duration of each shot was calculated from the time data. The accuracy of time duration of shot was verified by inter- and intra-observer reliability test and the error was 0.001 ± 0.135 s (Takahashi et al., 2007). The purpose of this study was to analyse the time duration of ground strokes in various court surfaces in men's singles tennis.

We used the computerised scorebook for tennis to collect the data from the three Grand Slam men's singles tennis tournaments (French Open, Wimbledon, U.S. Open) held in 2003 and 2004. The total for match data was 41 and total for points was 7349. The time duration of ground strokes was analysed from the data. The time duration of ground strokes was defined as the time difference between one player's shot and the opponent's. The time duration of ground strokes was recorded only when both players played ground strokes. The three Grand Slam tournaments that had different court surfaces and the player's situation whether server or receiver were compared. An ANOVA test and Scheffe's test were used for analysis.

The factor of the player's situation showed a significant difference ($P < 0.01$). The time duration of ground strokes for the server was 1.34 ± 0.23 s and for receiver was 1.37 ± 0.27 s. This result was influenced by the difference of tactics in service games and return games. The server has the advantage due to starting the rally by means of the serve. It leads the server to play more aggressively than the receiver. It affects the result of the time duration of ground strokes which for the server was shorter than for the receiver.

In the current study, we found the tactical perspective in ground strokes situation of tennis match. We can also apply those findings to tennis coaching by using the computerised scorebook for tennis.

Exercise referral: Is it effective at decreasing anthropometric measures and increasing physical activity?

S. R. Taylor¹, K. Williams², & K. A. Bond³

¹*Department of Sport and Exercise Science, NEWI, Plas Coch Campus, Wrexham, UK,* ²*Research Institute for Sport and Exercise Sciences, Liverpool John Moores University, Liverpool, UK,* and ³*School of Sport, Exercise and Sport Sciences, University of Chichester, Chichester, UK*

The health benefits of regular exercise are well documented and are widely acknowledged as successful interventions for both primary and secondary care, with health professionals encouraging patients to become more physically active. Exercise referral is a popular method for promoting and delivering physical activity to the population. The aim of this study was to investigate the effectiveness of an exercise referral scheme on anthropometric and physical activity measures.

Anthropometric data were collected from 31 patients (males $n = 14$, females $n = 17$) at baseline

(entry to exercise referral), after six intervention sessions and then 4 months following intervention. Data collected from the patients included stature, body mass, waist and hip circumferences, waist to hip ratio and BMI. Self-reported physical activity was assessed at the same time points using the short version International Physical Activity Questionnaire (IPAQ; Craig et al., 2003: *Medicine and Science in Sports and Exercise* 35:1381–1395).

Patients results showed that body mass ([mean \pm SE] pre 81.7 ± 2.1 kg, after six interventions 80.0 ± 2.0 kg and 4 months post-intervention 78.1 ± 1.7 kg, $P=0.001$), waist (97.3 ± 1.7 cm, 95.6 ± 1.7 cm, 94.2 ± 1.6 cm, $P < 0.001$) and hip (108.7 ± 1.6 cm, 107.6 ± 1.5 cm, 106.6 ± 1.3 cm, $P < 0.003$) circumferences, waist to hip ratio (0.895 ± 0.01 , 0.889 ± 0.01 , 0.884 ± 0.01 , $P=0.033$) and BMI (28.6 ± 0.7 kg \cdot m², 28.1 ± 0.7 kg \cdot m², 27.4 ± 0.5 kg \cdot m², $P=0.002$) all significantly decreased from baseline after the six intervention sessions and continued to decrease 4 months post-intervention. No significant effects of gender were identified expect for body mass ($P=0.013$), waist circumference ($P=0.044$) and waist to hip ratio ($P < 0.001$). Physical activity expressed as total met minutes per week increased from baseline (728.8 ± 201.8 MET \cdot min \cdot wk⁻¹) after the initial six sessions (1053.4 ± 211.9 MET \cdot min \cdot wk⁻¹), but thereafter declined (783.7 ± 166.5 MET \cdot min \cdot wk⁻¹, $P=0.063$). No significant sex-by-time interactions were identified for any of the analyses.

Participation in the exercise referral was only effective in achieving a relatively short-term (baseline to the initial six sessions) increase in physical activity as measured using a self-report physical activity questionnaire. Whereas more sustained reductions in body mass, waist and hip circumferences, waist to hip ratio and BMI were recorded.

Secular changes in body dimensions of 10–18 year-old Hungarian girls

Martina Uvacsek¹, J. Mészáros¹, & E. Van Praagh²

¹Faculty of Physical Education and Sport Sciences, Semmelweis University, Budapest, Hungary, and

²Laboratory of Exercise Biology UFRSTAPS, Université Blaise Pascal, Clermont-Ferrand, France

The health, social and economical status of a population can be described by means of observed changes in growth and development. According to Malina and Bouchard (1991: *Growth maturation and physical activity*. Champaign, IL: Human Kinetics Books), regular physical activity is one of the most important environmental conditions of harmonious

development in children. Unfortunately, the quantity of physical activity is continuously decreasing even in the highly-developed, well-fare societies (Laki & Nyerges, 2000: *Kalokagathia* 75th Anniversary Special Issue: 24–35; Bar Or, 2003: *Sport Science Exchange* 16:1–6). Nowadays, a sedentary life-style is considered as global evidence. The prevalence of obesity increased in Hungary in the last 20 years in harmony with social and economic changes, and with the increase of hypoactivity in pre-pubertal and pubertal children (Frenkl & Mészáros, 2002: *Hippocrates* 4:294–297).

In the present study, we assessed the constitution and body composition of 10- to 18-year-old girls living in the Budapest area. We also analysed differences in anthropometric data of girls investigated in 1983 and in 2003. The number of participating girls in the nine age groups was $n=4794$. Standard anthropometric methods were used (Weiner & Lourie, 1969: *Human biology: A guide to field methods*. IBP handbook. Oxford: Blackwell Scientific Publishers). Body fat content was estimated according to Parízkova (1961: *Metabolism* 10:794–807).

Significant differences were found in body height and body mass. The girls were generally taller and heavier during the second investigation. The latter also showed that the significantly taller stature was not accompanied by wider bone diameters. Such a general effect could be related to a lack of physical activity, after all the linear connection between bone density and regular physical activity has been proved (Malina & Bouchard, 1991). Average high body fat content and the high standard deviations explain the great prevalence of overweight and obesity in this population. High subcutaneous trunk fat could be an important risk factor in the metabolic X syndrome and cardiovascular diseases.

Towards a better understanding of ulnar wrist paraesthesia and entrapments in leisure and competitive sports

P. Van Roy, S. Provyn, H. Attanesyan, E. Cattrysse, & J. P. Clarys

Experimental Anatomy, Vrije Universiteit Brussel, Brussels, Belgium

Wrist problems entrapments and paraesthesia in particular are common in sports that entail gripping equipment. To understand the entrapment symptomatology of the different neurovascular passages at the volar aspect of the wrist, an anatomical revision of its respective tunnel is necessary because confusion and error has increased lately. This study will focus on the ulnar canal. Comparison of the original

description of the canal with definitions emanating from scientific papers, anatomical handbooks and internet websites reveal challenging differences, which may create clinical confusion. Cadaver dissections served to document the details of this clinical and functional area.

With the original report of Guyon (1861: *Bulletin de la société anatomique de Paris* 2nd series(6):184–186) as a reference, comparison was made (i) with 37 cadavers (74 wrists), (ii) with an internet search and (iii) with a bibliographic survey. The dissections allowed for the verification of Guyon's description were used to illustrate the findings. The internet search combined with a bibliographic survey of both clinical and research paper and the traditional anatomical literature allow for a complete ad hoc state of the art.

The dissection of 74 wrists confirmed all (100%) Guyon's original description. Out of the 2559 hits on the internet, papers and books written in English, French, German and Dutch were considered only. Both the internet websites and the published material are often presenting an erroneous image and/or explanation to demonstrate Guyon's canal. Many educational handbooks do not describe the ulnar canal at all.

The dissection and bibliometric survey suggest that the canal of Guyon has received multiple denominations including an erroneous confusion with the "canalis Pisohamatum" the tunnel for the N. ulnaris branch towards the hypothenar. Over the years this confusion is to be found in various sources e.g. on the internet sites and in scientific/clinical papers while in the "classical anatomy literature" both the ulnar and pisohamatum tunnels are too often forgotten.

Left-right asymmetries and other common variants of thoracic vertebrae

P. Van Roy, E. Cattrysse, & J. P. Clarys

Experimental Anatomy, Vrije Universiteit Brussel, Brussels, Belgium

Thoracic vertebrae present a light construction with relatively strong lever arms. Beside a gradual increase in size downwards, they also show several level dependent characteristics. The length of the transverse processes gradually decreases towards lower thoracic levels. On the other hand, length and craniocaudal inclination of the spinous processes gradually increase towards lower levels, except at the thoracolumbar transition, where shorter spinous processes approximate to the lumbar type. Transverse and spinous processes may present left-right asymmetries. Uncinate processes are typical at the

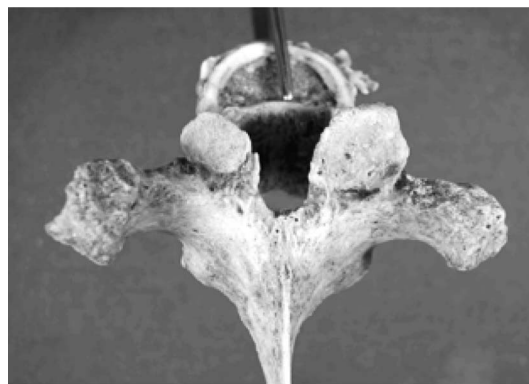


Figure 1. Articular tropism of zygapophyseal facets, caused by different surface area.

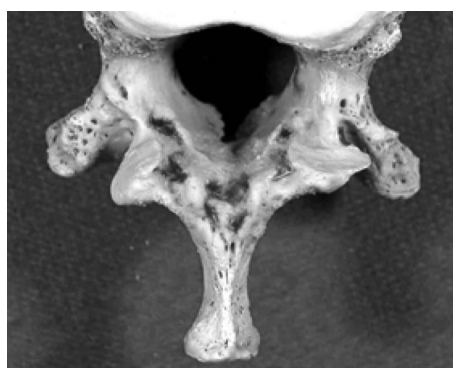


Figure 2. Articular tropism of zygapophyseal facets at the thoracolumbar transition, caused by different orientation.

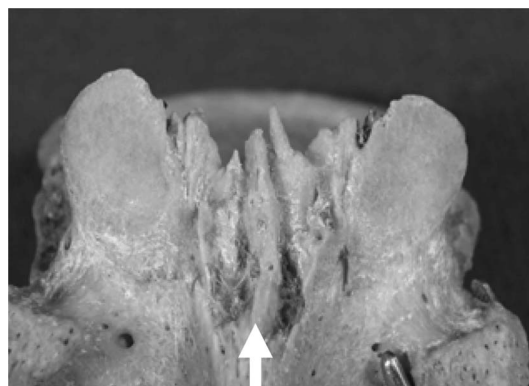


Figure 3. Ossification of the Lig. Flavum.

cervicothoracic transition. The thoracolumbar transition may be gradual or abrupt: a gradual is mostly situated around T11-T12, to a lesser extent around T12-L1, exceptionally around T10-T11. An abrupt transition is mostly seen at the level of T12-L1, to a lesser extent at T11-T12, exceptionally at L1-L2.

The vertebral bodies are kidney shaped, resulting in a rounded central spinal canal, which is relatively

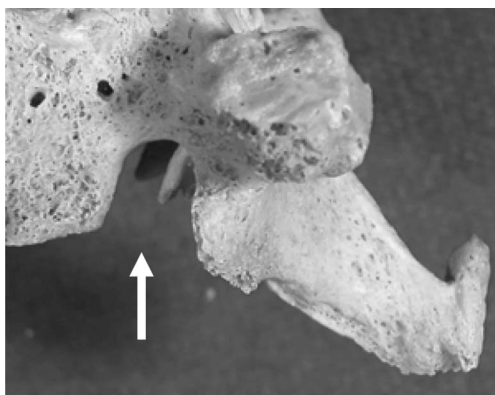


Figure 4. Remnants of enthesopathic process inside the capsular part of the Lig. Flavum.

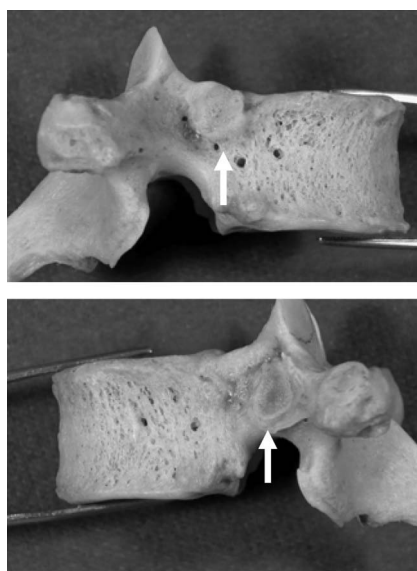


Figure 5. Articular tropism of the costal facets on the vertebral body.

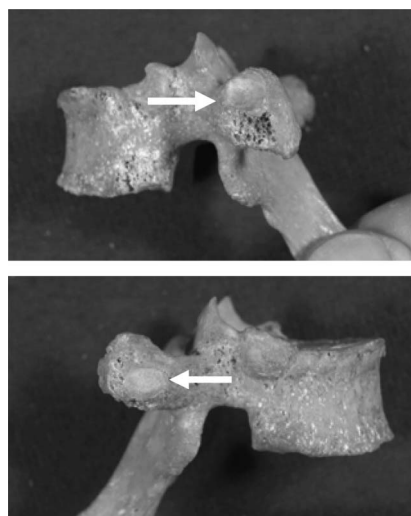


Figure 6. Articular tropism of the costal facets on the transverse processes.

narrow, especially at the levels from T4 to T9. A slight wedge shape of the vertebral body helps in building up the thoracic kyphosis. Left–right asymmetry of the anterior aspect of vertebral bodies has been brought in relationship with the course of the aorta in front of the left half of the vertebral bodies. Degenerative changes of their apophyseal rings represent another source of left–right differences. The combination of a relatively deep inferior intervertebral notch and a reduced disk height results in a mainly retrocorporeal position of thoracic intervertebral neurovascular foramina.

Thoracic zygapophyseal joints show typically flat facets. Steeply orientated in a circular configuration on the neural arch they facilitate axial rotation. Articular tropism may result from left–right differences in inclination, curvature, length, width, surface area, implantation or osteophytosis of the articular facets. Whereas degenerative enlargement and osteophytosis may cause articular tropism at almost every thoracic level, different inclination and curvature of articular facets preferably occurs at the thoracolumbar transition. In between left and right thoracic facets, ossification of the ligamentum flavum may lead to a fanciful additional bony ridge on the neural arch. Enthesopathic development inside the capsular part of the ligament results in bony spurs, which may create an obstacle at the intervertebral foramen.

In general, the head of a rib articulates with the superior semicircular costal facet of the numerically corresponding vertebral body (n) and with the inferior semicircular costal facet of the vertebral body one level higher ($n - 1$). Hereby, the ridge of the rib head is connected to the intervertebral disk in between the articulating vertebrae. The rib tubercle articulates with the costal facet of the transverse process of the numerically corresponding vertebra (n). Because the first rib does not articulate with C7, the body of the first thoracic vertebra shows a left and right circular costal facet for the first rib. Also the vertebral bodies of T10, T11 and T12 carry only one pair of circular costal facets (exceptionally also T9); from T10 to T12, the position of these costal facets gradually shifts towards the waist of the vertebral body and towards the pedicle. Whereas in the upper half of the thoracic spine, transverse costal facets are more concave and situated at the anterior aspect of the transverse process, in the lower half of the thoracic spine these facets reveal a flat configuration and lie on the superior aspect of the transverse processes; transverse costal facets are absent at T11 and T12. Articular tropism of costal facets mainly deals with left–right differences of curvature, size and localisation of the facets on the vertebral body or transverse process.

The biology of sleep

Eus J. W. Van Someren

*Netherlands Institute for Neuroscience and VU
University Medical Center, Amsterdam,
Netherlands*

We spend one third of our life sleeping, and most of us are convinced that sleep plays an essential role in maintaining bodily and especially brain functions. During the last decade, there has been a renewed interest in the role of sleep in memory and learning. By application of new tools, neuroscience had given us a number of insights of processes in the brain that may be involved in the role of sleep in learning. Relevant to the present meeting, the material is focused on the role of sleep in the acquisition of new skills. After a brief overview of what happens in the brain during sleep, examples show how one could profit from sleep after acquisition of new skills. Our most recent data even show that sleep may even increase an individuals *de novo* level of performance after observing someone else learning the skill. So, it might be of use to watch a soccer match on Friday night to improve one's own performance playing soccer on Saturday morning.

The effect of breast support on kinetics during overground running performance

J. White¹, J. Scurr¹, & N. Smith²

¹*Department of Sport and Exercise Science, University of Portsmouth, Spinnaker Building, Portsmouth, UK and*
²*School of Sport, Exercise and Health Sciences, University of Chichester, Chichester, UK*

Changes in ground reaction forces (GRFs) that result from different breast support conditions have yet to be reported in the literature and may have implications for sports performance. Previous researchers have not explored the impact that diverse bra designs may have on a female's running performance overground. The aim of this investigation was to compare kinetic variables in a "no bra", "everyday bra" and two "sports bra" conditions. Following ethical approval, eight female participants with D cup breasts (age 24.80 ± 6.40 years, height 1.663 ± 0.041 m, body mass 66.24 ± 7.13 kg, band size 34 ± 1.85 (mean \pm s)) had retro-reflective markers placed on the left and right nipples, anterior superior iliac spines (ASIS) and clavicles (directly superior to the nipples). Five calibrated ProReflex infra-red cameras (100 Hz, Qualisys, Sweden) measured 3D displacement of markers and synchronised kinetic data were collected using a force platform (500 Hz, Kistler 9281CA, Switzerland). Five suc-

cessful running trials ($3 \text{ m} \cdot \text{s}^{-1} \pm 0.05 \text{ m} \cdot \text{s}^{-1}$) were recorded for each breast support condition in a randomised order. A repeated measures one-way ANOVA revealed a significantly higher medial GRF in the no bra condition (0.15 bw) compared with the compression sports bra support condition (0.12 bw) ($F = 3.643_{(3, 21)}$, $P = 0.029$). Although not significant, peak vertical force increased as breast support increased, supporting the findings of Shivitz (2001: Eugene, Oregon: Microform Publications). Medio-lateral impulse ($0.0057 \text{ bw} \cdot \text{s}$) and loading rate ($32.66 \text{ bw} \cdot \text{s}^{-1}$) were greatest in the no bra condition. Anteroposterior force variables were unaffected by changes in breast support. Breast displacement data were comparable with previous breast motion studies. Findings suggest that inadequate breast support affect a female's running kinetics, which may have negative kinematic and physiological consequences on sports performance. Future research should consider these variables.

Influence of a heart rate biofeedback intervention programme on exercise intensity perception in secondary school students

M. Zabala¹, D. Doran², P. Femia¹, C. Sánchez¹, J. Ramírez-Lechuga¹, & L. Dugdill³

¹*Faculty of Education Sciences, University of Granada, Granada, Spain,* ²*Research Institute for Sport and Exercise Sciences, Liverpool John Moores University, Liverpool, UK,* and ³*Faculty of Health Sciences and Social Care, University of Salford, Manchester, UK*

The aim of the study was to test if secondary school students could perceive exercise intensity accurately when practicing physical activity after a specific intervention programme based on heart rate biofeedback and the utilisation of a rating of perceived exertion scale (RPE 6-20).

Two experimental groups of students from 3rd level (15 years) of a secondary school of Granada (Spain) were selected – nine girls and nine boys each ($n = 36$). Also an equivalent control group of eight boys and seven girls ($n = 15$) was included. A quasiexperimental design was carried out developing 12 specific lessons in the natural context of physical education lessons. After a first test lesson, the treatment carried out consisted in 11 practical lessons and a theoretical-practical one, in which students had to perceive their own heart rate and compare it with the one registered individually in a heart rate monitor at the moment of finishing each of the six pre-selected tasks performed in the main part of the lesson (significant, aerobic, constant, and involving great muscle mass). Also, students had to

give an RPE value (RPE overall) as an average for the task. Perceived heart rate was related to the measured heart rate at the same moment, and RPE was related to measured average heart rate. After the treatment, a post-test lesson was developed and 3 months later a retest lesson to check if any retention of learning could exist. During the test lessons heart rate biofeedback was covered in the monitors.

No significant differences were observed in any variable between the experimental groups so that they were taken as one for the statistical analyses (Friedman test and Wilcoxon *post hoc*). In the pre-test, errors ranging from 30 to 50 beats · min⁻¹ were observed, although these differences were clearly minimised in the experimental group to a range of 5–10 beats · min⁻¹ for heart rate, and 12–26 beats · min⁻¹ for RPE (using the equation RPE_{Ex10} = perceived average heart rate, that was found to underestimate measured heart rate). The control group did not show any change.

Three months later the retention of the learning was observed for both relationships, although the error in perception was increased showing significant differences in some cases of pos-test/re-test comparison.

The proposed intervention programme was effective in its context when practicing constant and aerobic physical activity, showing a significant improvement in the perception of exercise intensity not only in terms of heart rate perception, but also in the use of 6–20 rating of perceived exertion scale.

Determination of a technical learning line for Big Air snowboard

E. Zinzen¹, J. Pannier¹, & P. Clarys²

¹Department of Movement Education and Sports Training, Vrije Universiteit Brussel, Brussels, Belgium and ²Department of Human Biomechanics and Biometry, Vrije Universiteit Brussel, Brussels, Belgium

Big Air, one of the snowboard sub-disciplines, competition is scored by the difficulty and the performance level of a jump from a ski-jump (a ski-

jump = Big Air). Being a relatively young sport in evolution, little is known about learning lines for Big Air competition.

The aim of this study was to determine whether there is an ideal age to start with Big Air, how long it takes to reach world top level and what abilities one should have during different development stages to reach the top level.

A retrospective questionnaire was developed in close collaboration with experts in the field and tested on lower level Big Air athletes. Snowboard techniques and skills were grouped in levels of increasing complexity, with beginners classified in level 1 and top world cup techniques in level 10. In total 34 athletes from the FIS (International Ski Federation) World Cup participated in the study. Basically, they had to indicate at what level they situated themselves at different ages.

On average the athletes started at 11.8 ± 2.58 years of age. They started competition when they reached the age of 15.3 ± 2.73 and were selected for first World Cup performances on the age of 18.9 ± 2.84 years which can be considered as a rather fast evolution. There was a wide range of starting ages but the average time to reach the top (level 10) was more or less the same: ± 7 years, however only 21 of the 34 subjects had reached this level. By calculating the P50 of each level we could construct the ideal evolution (learning line) on technical skills. No significant ($P < 0.05$) differences in evolution between junior and senior snowboard riders (t -test), between riders from a mountain country and a flat country (t -test), between the different starting ages (ANOVA) and spin direction (χ^2) were found.

Results can be easily placed in talent identification models (e.g. Williams & Reilly, 2000: *Journal of Sports Sciences* 18:657–667) and/or career transitions models (e.g. Wylleman, 2004: *Psychology of Sport Exercise* 5:7–20) which will enable snowboard coaches to determine at which stage their athletes are and how they should evolve to become Big Air World Cup level athletes. The small number of subjects and the retrospective method lead us to conclude that this technical learning line constructed for snowboarding needs further research for its confirmation.