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Abstracts

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## WEDNESDAY 21 OCTOBER PAPERS AT A GLANCE

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1700-1800	Plenary Keynote	Lessons learned in 30 years of Sports Medicine	Dr Peter Brukner	MacArthur's Ballroom	1

1

### Lessons learned in 30 years of Sports Medicine

Peter Brukner OAM, MBBS, FACSP, FASMF • Professor of Sports Medicine, La Trobe University, Melbourne • Australian Cricket Team Doctor

Thirty three years ago when I returned to Australia from a few years working in the UK, I wanted to pursue my interest in sports medicine. At the time, there was virtually no-one working in full time sports medicine practice, team doctors were very part time, there was no formal post-graduate qualification in sports medicine, and no way of distinguishing those with any experience in sports medicine from those with none.

I started work in general practice, did the part time RACGP/ASMF course and gradually developed a sports medicine practice.

Five years later I decided to try full time sports medicine and give it a go for 6 months. In the space of a few years a number of multi-disciplinary sports medicine centres were established, full time sports medicine practice became quite common, a College was formed to oversee training and qualifications in sports medicine, commitment as a team doctor in professional sport went from after hours to part time to full time, university positions were established, Olympic teams positions for sports doctors expanded dramatically, and the public became increasingly aware that there was a group of knowledgeable, experienced health professionals with expertise in sports medicine.

In that time, there have been lots of lessons learned by myself and others and I would like to share some of those with you.



## THURSDAY 22 OCTOBER PAPERS AT A GLANCE

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Y. Hellsten<sup>1\*</sup> • <sup>1</sup>The Department of Nutrition, Exercise and Sport, University of Copenhagen, Denmark

Endurance exercise requires a substantial amount of oxygen to be delivered via the blood to the active muscle for aerobic energy production. The magnitude of energy production by the muscle is related to the intensity of exercise and, accordingly, there is a close relationship between submaximal exercise intensities and the rate of blood flow and oxygen delivery to the muscle. When exercise is begun, cardiac output is increased and the arterioles in the active muscle vasodilate to allow for an increase in blood flow. The regulation of arteriolar vasodilation in muscle is a highly complex and precise process which enables rapid changes in blood flow and levels that during exercise can be as much as 100-fold above that at rest. Overall, vasodilation is regulated by a balance between constrictive sympathetic activity and locally formed vasodilators as well as compounds that can modulate the effect of sympathetic activity, so called sympatholysis. This key note lecture addresses current knowledge on how blood flow to the muscle is regulated during exercise but also covers how exercise training, physical inactivity, aging and lifestyle related disease affects muscle blood flow and its regulation.

### SYMPOSIUM: Hamstring strain injury – structural and functional considerations for prevention, rehabilitation and return to play.

Dr Anthony Shield, Dr David Opar, Mr Ryan Timmins, Mr Matthew Bourne

The presentation would focus on the work of our Hamstring Injury Group research team (headed by Dr Anthony Shield) over the past 3 years, during which time we have published 12 papers specifically on hamstring strain injury and have another 4-6 papers due for submission in the first 6 months of 2015. The symposium would cover:

- The evidence of eccentric strength (using our field test of eccentric hamstring strength) as a risk factors for HSI in Australian football, soccer, rugby union and cricket.
- The role of eccentric hamstring inhibition following injury and its role in reinjury.
- The use of fMRI to assess the activation patterns of commonly employed hamstring prevention and rehabilitation exercises.
- The role of biceps femoris muscle architecture in identifying at risk athletes and architectural markers to guide return to play criteria.

### Hyperventilation-induced respiratory alkalosis increases the number of repetitions to be able to perform during resistance training

A. Sakamoto<sup>1\*</sup> • H. Naito<sup>1</sup> • C. Chow<sup>2</sup>

<sup>1</sup>Institute of Health and Sports Science & Medicine, Juntendo University • <sup>2</sup>Discipline of Exercise and Sport Science, The University of Sydney

**Background:** During intermittent high-intensity exercise, the accumulation of hydrogen ions or the resulting fall in intramuscular pH has been considered a major fatigue mechanism. Our recent study showed that reversing the acidic muscle milieu by implementing hyperventilation (HV) during recovery periods that separated short pedaling sprints was effective in attenuating the performance decrement. The present study investigated whether HV-induced respiratory alkalosis could be applied to resistance training, expecting an increased number of repetitions to be able to perform with HV.

**Methods:** Eleven power-trained athletes (1RM: 102.5-162.5 kg for bench press and 170.3-246.8 kg for leg press) performed 6 sets of bench press and leg press at 80% 1RM on the same day with and without HV during the last 30-s of 5-min inter-set recovery on 2 separate occasions (protocol A and B). HV was implemented before the 1st, 3rd and 5th sets for protocol A, and before the 2nd, 4th and 6th sets for protocol B ( $P_{ET}CO_2$ : below 25 mmHg). Subjects breathed spontaneously for the entire 5-min during the alternate non-HV recovery periods. In each set, lifting was continued until failure with the number of successful repetitions being recorded. Electro-goniometers were attached at the elbow and the knee joints to calculate the joint angular velocity and acceleration per repetition. Blood  $[La^-]$  and pH were examined to report physiological strains of the exercise, and pH recovery resulting from HV.

**Results:** HV increased blood pH by  $0.077 \pm 0.024$  before the subsequent set ( $p < 0.001$ ). HV either increased (leg press,  $p < 0.05$ ) or maintained (bench press) the repetition number compared to the number achieved during the previous non-HV set. The repetitions performed during non-HV set were always fewer compared to the previous HV set ( $P < 0.005$ ). The sum of repetitions (protocol A + B) was greater for HV than non-HV sets in both bench press ( $44 \pm 10$  vs.  $36 \pm 10$  reps,  $p = 0.001$ ) and leg press ( $64 \pm 9$  vs.  $50 \pm 15$  reps,  $p < 0.001$ ). After the exercise, the blood  $[La^-]$  was greater ( $9.82 \pm 2.66$  vs.  $6.87 \pm 1.47$  mM,  $p < 0.001$ ) and pH was lower ( $7.303 \pm 0.055$  vs.  $7.340 \pm 0.030$ ,  $p < 0.001$ ) for leg press than bench press. The goniometer data are under analysis.

**Discussion:** HV countered the reduction of repetitions associated with fatigue, with a more pronounced ergogenic effect for leg press, which incurred a greater physiological strain than bench press. The increased volume of intense training may be translated into a greater training efficacy.

### Cycling inhibits age-related decreases in muscle thickness of the lower extremities and maximum oxygen uptake

H. Ozaki<sup>1\*</sup> • T. Kitada<sup>2</sup> • T. Abe<sup>3</sup> • S. Machida<sup>2</sup> • H. Naito<sup>2</sup> • S. Katamoto<sup>2</sup>

<sup>1</sup>School of Health and Sports Science, Juntendo University • <sup>2</sup>Graduate School of Health and Sports Science, Juntendo University • <sup>3</sup>National Institute of Fitness and Sports in Kanoya

**Background:** Cycling training is capable of eliciting thigh muscle hypertrophy in addition to maximum oxygen uptake ( $VO_{2max}$ ) in untrained young and older adults when performed regularly for prolonged periods (i.e., over months rather than weeks). Therefore, cycling training over the years in

middle-aged and older populations may contribute to inhibiting age-related decreases in muscle size of the lower extremities as well as  $\text{VO}_2\text{max}$ . The purpose of this study was to compare muscle size and  $\text{VO}_2\text{max}$  between young adults and middle-aged and older recreational cyclists.

**Methods:** Nine untrained or moderately active young men (YC group; age:  $27 \pm 1$  years [range, 25–30 years], height:  $174.1 \pm 1.9$  cm, weight:  $66.5 \pm 2.0$  kg, and body mass index [BMI]:  $21.9 \pm 0.5$  kg/m<sup>2</sup>) and eight middle-aged and older recreational cyclists (MOC group; age:  $55 \pm 2$  years [range, 48–62 years], height:  $171.8 \pm 2.1$  cm, weight:  $66.7 \pm 2.5$  kg, BMI:  $22.6 \pm 0.7$  kg/m<sup>2</sup>, and training experience:  $12 \pm 4$  years [at least once a week for 2 years]) volunteered to participate in this study. Subjects who performed regular exercises, except cycling training, were excluded from this study. Muscle thickness (MTH) was measured using B-mode ultrasound at four sites on the anterior and posterior aspects of the thigh (at 50% of the thigh length) and the lower leg (at 30% of the lower leg length). The MTH was expressed in terms relative to limb length (MTH/L).  $\text{VO}_2$  was measured on an ergometer using an automated metabolic monitor. Additionally, the chair-stand test which required subjects to stand up from a seated position as many times as possible within 30 seconds was performed, and the maximum walking time was measured using a 10-meter walkway.

**Results:** There were no significant differences in mean  $\text{VO}_2\text{max}$  and maximum heart rate between YC ( $45.1 \pm 1.4$  mL/kg/min and  $188 \pm 4$  bpm, respectively) and MOC ( $44.8 \pm 1.4$  mL/kg/min and  $180 \pm 1$  bpm, respectively) groups. Among MOC, the  $\text{VO}_2\text{max}$  was significantly ( $p < 0.05$ ,  $r = 0.754$ ) correlated with training distance (km per month). There were no differences in MTH/L of the anterior and posterior aspects of the thigh and lower leg between the two groups. The MTH of the anterior aspect of the thigh was significantly ( $p < 0.05$ ,  $r = 0.738$ ) correlated with training distance in MOC groups. Furthermore, there were no significant differences in the values of the chair-stand test and maximum walking time between YC and MOC groups.

**Discussion:** Compared to young adults, middle-aged and older recreational cyclists have the same muscle size in the lower extremities and  $\text{VO}_2\text{max}$ .

## 6

## Modeling lung function reveals serious errors in current methods of indirect calorimetry

R. Robergs<sup>1\*</sup>

<sup>1</sup>School of Human Movement Studies, Charles Sturt University

**Introduction:** Expired gas analysis indirect calorimetry (EGAIC) is used routinely in basic and applied physiology, medicine and nutrition/dietetics. Most laboratories rely on commercial systems, yet there is seldom sufficient research validation of these systems and their components. Furthermore, application of rational thought and logic raises concerns about numerous assumptions of current systems, with particular reference to not accounting for air mixing in the lung conducting zone during both inspiration and expiration.

**Methods:** Lung function was modeled using multiple one-way valve assemblies, tubing to mimic the lung conducting zone, Douglas bags, expired gas mixing bags, and two sets of electronic rapid response oxygen ( $\text{O}_2$ ) and carbon dioxide ( $\text{CO}_2$ ) analyzers. Lung function was modeled based on the flushing of tubing for the lung conducting zone with room air between each expired gas maneuver. Configurations of equipment were completed to test for differences in ventilation and expired gas fractions for a) the direct connection of a 2 L flow through mixing bag to the expired port of a mouthpiece, b) Douglas bag expired gas collection and c) 1.524 m of low resistance tubing to a Douglas bag. In addition, the extent of conducting zone air contamination was quantified by air sampling from a known gas mix to air consequent to expired contamination from a dead space (~200 mL) of room air.

**Results:** The room air contamination of the lung conducting zone caused no significant difference from reference to expired  $\text{O}_2$  and  $\text{CO}_2$  gas fractions for the 2 L flow through mixing bag connected to the expired port of the mouthpiece ( $14.96 \pm 0.22$  vs.  $14.99 \pm 0.13$  % $\text{O}_2$ ;  $5.27 \pm 0.16$  vs.  $5.23 \pm 0.09$  % $\text{CO}_2$ ). For Douglas bag and Douglas bag with tubing configurations, expired gas fractions changed from  $15.51 \pm 0.12$  to  $15.68 \pm 0.08$ , respectively for  $\text{O}_2$  and  $4.97 \pm 0.24$  to  $4.71 \pm 0.18$ , respectively for  $\text{CO}_2$ . Conducting zone contamination of end tidal % $\text{O}_2$  by room air revealed the following change;  $16.02 \pm 0.58$  to  $17.98 \pm 1.27$ , for mimicked alveolar vs. end tidal, respectively.

**Discussion:** The presence of room air in the conducting zone at end inspiration, and alveolar air at end-expiration, causes significant alteration of mixed and end-tidal gas fractions for different methods of expired gas sampling in EGAIC. The presence of expired tubing prior to a Douglas bag collection exaggerates this contamination. The positioning of a flow through 2 L mixing bag directly to the expired port of a mouthpiece does not cause change in end tidal gas fractions, thereby overcoming this expired contamination.

## 7

## Effect of body composition on core temperature responses to post-exercise cold water immersion.

AWARD FINALIST

J. Stephens<sup>1 2\*</sup> • S. Halson<sup>1</sup> • J. Vaile<sup>1</sup> • G. Slater<sup>2</sup> • C. Askew<sup>2</sup>

<sup>1</sup>Department of Physiology, Australian Institute of Sport • <sup>2</sup>School of Health and Sport Sciences, University of the Sunshine Coast

**Introduction:** Protocols for post-exercise cold water immersion (CWI) currently utilizes a 'one size fits' all approach, as athletes of the same team/group complete the same protocol regardless of individual characteristics. It is hypothesised that body composition may affect an athlete's thermal responses to hydrotherapy. This study aimed to compare the time-course of core temperature ( $T_c$ ) responses to post-exercise CWI between three distinct body composition groups.

**Methods:** 27 trained male (Age  $32.6 \pm 7.7$ y,  $\text{VO}_{2\text{max}}$   $4.6 \pm 0.5$ L $\cdot\text{min}^{-1}$ ) participants were recruited into one of three body composition categories: i) low mass and low fat (mf) if their body mass index (BMI) was  $\leq 21.0$  and body fat percentage (BF%) was  $\leq 13.0$ % ( $n=9$ ), ii) high mass and low fat (Mf): BMI  $\geq 25.0$ , BF%  $\leq 13.0$ % ( $n=9$ ) or iii) high mass and high fat (MF): BMI  $\geq 25.0$ , BF%  $\geq 18.0$ % ( $n=9$ ). Body composition was assessed by dual energy x-ray absorptiometry (DXA). Participants completed three experimental trials in a randomised counterbalanced cross-over design. Each trial consisted of cycling at 75% of peak power output until  $T_c$  reached  $38.5^\circ\text{C}$ , followed by one of three recovery modalities i) CWI; 15 min whole body immersion (excluding the head) in  $15^\circ\text{C}$  water, ii) hot water immersion (HWI); 15 min whole body immersion in  $38^\circ\text{C}$  water, or iii) control (CON): 15 min seated rest. Finally participants rested in a supine position for 240 min post-recovery.  $T_c$  was measured by a disposable rectal thermometer (Monatherm, Mallinckrodt, USA) with data logged continuously (Squirrel 2040-2F16, Grant Instruments, England) throughout the trial.

**Results:** There were no significant differences in  $T_c$  between body composition groups at any time-point during the CON and HWI trials. Regardless of body composition  $T_c$  decreased following CWI, with peak decrement occurring 60 min post-immersion (mf:  $36.2 \pm 0.4^\circ\text{C}$ , Mf:  $36.5 \pm 0.6^\circ\text{C}$ , MF:

36.6 ± 0.4°C).  $T_{c}$  in the mf group was significantly lower than the Mf group at 30 min post-recovery (mf: 36.5 ± 0.5, Mf: 36.9 ± 0.4°C,  $P \leq 0.05$ ).  $T_{c}$  in the mf group was lower than the MF group at 30 (mf: 36.5 ± 0.5°C, MF: 37.0 ± 0.4°C,  $P \leq 0.05$ ), 60 (mf: 36.2 ± 0.4°C, MF: 36.6 ± 0.4°C,  $P \leq 0.05$ ) and 90 (mf: 36.2 ± 0.5°C, MF: 36.7 ± 0.4°C,  $P \leq 0.05$ ) min post-recovery.

**Discussion:** This study confirms that differences in body composition influence  $T_{c}$  responses to post-exercise CWI, which may influence the benefits to performance recovery. There is a need to develop individualised CWI protocols to maximize recovery benefits for individual athletes.

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## No difference in muscle damage between well-trained masters and young triathletes following regular intense endurance exercise

T. Doering<sup>1\*</sup> • P. Reaburn<sup>1</sup> • N. Borges<sup>1</sup> • D. Jenkins<sup>2</sup>

<sup>1</sup>School of Medical and Applied Sciences, CQUniversity, Rockhampton QLD • <sup>2</sup>School of Human Movement Studies, The University of Queensland, St Lucia QLD

**Introduction:** Previous research has suggested masters athletes require longer than younger athletes to recover following muscle-damaging exercise. Whether older muscle takes longer to repair from muscle damage, or whether older muscle is susceptible to greater levels of muscle damage has been examined in older healthy but untrained individuals. However, limited research has examined muscle damage in well-trained masters athletes. The purpose of the present study was to examine the effect of age on creatine kinase (CK) concentration (a marker of muscle damage) over a 48 h period of regular intense endurance exercise in well-trained athletes.

**Methods:** Six well-trained young (26.8 ± 1.7 (range 25-29) years, 72.0 ± 5.0 kg,  $VO_{2peak}$  62.3 ± 1.5 mL.kg<sup>-1</sup>.min<sup>-1</sup>) and five well-trained masters (53.2 ± 1.6 (range 52-56) years, 79.7 ± 6.9 kg,  $VO_{2peak}$  55.7 ± 6.9 mL.kg<sup>-1</sup>.min<sup>-1</sup>) male triathletes completed one standardised downhill run, and three cycling time-trials (20km) at 10, 24 and 48 h following the downhill run. Diet and exercise was standardised for the 24 h prior to, and for the duration of the study. Capillary blood (32 uL) was sampled immediately prior to and 1 h following the downhill run, and again before each cycling time trial. Samples were analysed for CK concentration using a *Reflotron* desktop analyser. Repeated measures ANOVA was used to determine time and group x time effects, and alpha was set at 0.05. Group data are presented as mean ± standard deviation.

**Results:** In masters triathletes, CK concentration at 0, 1, 10, 24, and 48 h were 92 ± 42, 265 ± 153, 661 ± 441, 701 ± 362, and 619 ± 270 u/L, respectively. In young triathletes, CK concentration at 0, 1, 10, 24, and 48 h were 109 ± 40, 335 ± 189, 696 ± 390, 644 ± 318, and 456 ± 294 u/L, respectively. While there was a significant effect of time on CK concentration for both groups ( $p < 0.05$ ), there was no between-group difference in CK concentration at any time point ( $p > 0.05$ ).

**Discussion:** This study has shown that over a 48 h period of regular intense endurance exercise inclusive of muscle-damaging running, masters and young triathletes display similar increases in CK concentration. These results suggest that the protective effect of prior eccentric exercise training protects the muscle of masters athletes against higher levels of muscle damage than observed in younger similarly-trained athletes. The present results suggest that the longer recovery durations previously observed in masters athletes following muscle-damaging exercise may be due to poorer repair mechanisms within skeletal muscle, and not due to age-related increases in muscle damage following exercise.

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## Positive swim pacing improves subsequent sprint distance triathlon performance in well-trained athletes

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**Background:** Triathlon is a multi-sport event that consists of sequential swim, cycle and run disciplines. The manipulation of pacing during triathlon is crucial to performance but complex due to the importance of optimising energy expenditure throughout the three different locomotion modes. Although the effect of pacing during cycling on subsequent running performance is well documented, the majority of these studies lack an initial swim discipline, which may inaccurately reflect the metabolic demands and pacing strategies adopted during a triathlon. The purpose of this study was to investigate the effect of three swim pacing strategies on subsequent performance during a sprint distance triathlon (SDT).

**Methods:** Nine well-trained male triathletes completed five experimental sessions, including a graded running exhaustion test, a 750 m swim time-trial (STT), and three SDTs. The swim time of the SDTs were matched, but pacing was manipulated to be either positive (i.e. speed gradually decreasing from 92 to 73% STT), negative (i.e. speed gradually increasing from 73 to 92% STT) or even (constant 82.5% STT). The remaining disciplines were completed at a self-selected maximal pace. Speed over the entire triathlon, power output during the cycle discipline, rating of perceived exertion (RPE) for each discipline and heart rate during the cycle and run were determined.

**Results:** Faster cycle and overall triathlon times were achieved with positive swim pacing (30.5 ± 1.8 and 65.9 ± 4.0 min respectively), as compared with the even (31.4 ± 1.0 and 67.7 ± 3.9 min respectively) and negative (31.8 ± 1.6 and 67.3 ± 3.7 min respectively) pacing strategies. Positive swim pacing elicited a lower RPE (9 ± 2) than negative swim pacing (11 ± 2). No differences were observed in the other measured variables.

**Discussion:** This study demonstrated superior cycle and subsequently overall performance during a sprint distance triathlon when adopting a positive swim pacing strategy, as compared with negative and even swim pacing strategies. Despite a matched swim time, a higher cycling power output was elicited after the positive pacing swim during the earlier stages of the cycle discipline, compared with the negative and even pacing strategies. This could be due to a lower sense of fatigue following the positively paced swim as indicated by the lower rating of perceived exertion.

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## Ice ingestion improves cycling in hot, humid conditions with no change in energy expenditure or sweat response

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**Introduction:** Previous research indicates that ice ingestion is an effective pre-cooling technique for improving endurance performance in the heat. Why performance is improved however, remains speculative, with little evidence to support proposed theories. This study aimed to examine the effects of pre-cooling via ice ingestion on the body's metabolic output and sweat response when exercising in hot, humid conditions.

**Methods:** Eleven male endurance athletes with mean age ( $26.4 \pm 6.1$  y), height ( $181.2 \pm 5.8$  cm) and body-mass ( $79.1 \pm 7.1$  kg) participated in the study. Participants completed 3 x 800 kJ cycle time trials in hot, humid conditions ( $35.2 \pm 0.2^\circ\text{C}$ ,  $57.2 \pm 4.5\%$  RH) a week apart, in a randomised order. The 800 kJ cycle time trial was preceded by a 30 min pre-cooling period whereby  $7\text{g}\cdot\text{kg}^{-1}$  of crushed ice (ICE) or room temperature water (CON) was consumed. The ventilated capsule method was used for the measurement of sweat onset and sweat rate. This involved nitrogen gas being fed into two capsules placed on the skin with the resulting increase in humidity within the capsule being measured by a capacitance hygrometer. Expired air was collected and fed through a metabolic cart to analyse oxygen and carbon dioxide content. From this, volume of oxygen consumed and respiratory exchange ratio were calculated.

**Results:** Participants completed the 800 kJ CTT faster in ICE ( $2696 \pm 434$  s) compared with CON ( $2796 \pm 456$  s) ( $p=0.011$ ). Core temperature decreased following pre-cooling with ICE ( $-1.42 \pm 0.85^\circ\text{C}$ ) compared with CON ( $-0.18 \pm 0.15^\circ\text{C}$ ) and remained lower until the 300 kJ mark of the cycle time trial ( $p<0.05$ ,  $d>1.0$ ). This corresponded with a lower rate of heat storage during the pre-cooling period ( $p<0.05$ ,  $d>0.8$ ) and a higher rate of heat storage during the cycle time trial ( $p<0.05$ ,  $d>0.7$ ) in ICE compared with CON. There was no significant difference in respiratory exchange ratio, volume of oxygen consumed, sweat response, skin temperature, heart rate, perceived thirst or perceived exertion between conditions ( $p>0.05$ ,  $d<0.5$ ).

**Discussion:** Ice ingestion improved endurance performance despite no change in energy expenditure, sweating, hydration or perceived effort. Pre-cooling with ice ingestion may allow for more efficient use of energy stores without excess fluid loss through sweat during exercise. This may have resulted in reduced perception of effort, leading to an increase in power output. Along with this, an increase in heat storage capacity within the body's core allowed for an increased rate of heat storage during exercise.

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## Effect of velocity and familiarisation on reliability of isokinetic dynamometry in healthy adults: A test-retest reliability study

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**Introduction:** Reliability of isokinetic strength testing is known to vary between machines, yet no previous studies have established the reliability of the HUMAC-NORM isokinetic dynamometer. Additionally, there are discrepancies in the literature regarding the most reliable velocities for testing. Practice-based improvement (PBI) is known to affect the reliability of repeated isokinetic strength assessment due to a learning effect, but there is a lack of standardisation in the amount of practice or familiarisation, participants receive prior to testing. The objectives of this study therefore were to: a) measure the test-retest reliability of the HUMAC-NORM, b) determine the reliability of isokinetic testing at different velocities, and c) establish the extent of familiarisation required to minimise PBI and obtain reliable isokinetic knee flexion and extension measures.

**Methods:** Healthy participants ( $N=70$ ; mean age 21.9 years; range 18-34, males 50%) with no experience in isokinetic dynamometry were recruited as a sample of convenience from the University of Newcastle. Using the HUMAC-NORM, participants completed five repetitions of concentric knee flexion and extension at 60, 120, 180 and  $240^\circ/\text{s}$  on four occasions, each one week apart. Peak torque, angle of peak torque, total work and average power were recorded. Reliability was determined using percentage change in the mean (group reliability), typical error (within-subject reliability) and intraclass correlation coefficients (ICC; rank-order reliability).

**Results:** Group data achieved an excellent level of reliability after two trials for knee extension across all outcome measures (e.g. change in mean for knee extension angle of peak torque  $60^\circ/\text{s}$  Trial 2-1: 13.2%, 95% CI 8.3 to 18.3; Trial 3-2: 1.0%, 95% CI -3.1 to 5.3) but was more variable for knee flexion at velocities  $>120^\circ/\text{s}$ . Within-subject reliability was acceptable after two trials, but was more variable at higher velocities, particularly for knee flexion (typical error for knee extension peak torque  $240^\circ/\text{s}$  Trial 2-1: 13.2%, 95% CI 10.9 to 16.8; Trial 3-2: 5.6%, 95% CI 4.7 to 7.1). ICCs were acceptable for knee flexion and extension after two trials at all velocities (ICC for knee flexion total work  $120^\circ/\text{s}$  Trial 2-1: 0.43, 95% CI 0.17 to 0.63; Trial 3-2: 0.83, 95% CI 0.72 to 0.90).

**Discussion:** The HUMAC-NORM demonstrates excellent test-retest reliability when assessing isokinetic strength of groups, and reasonable reliability for individuals, after repeated testing. One familiarisation session is recommended prior to testing to minimise the impact of PBI. However, at higher velocities more familiarisation is beneficial, particularly for individuals and knee flexion measures.

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## Cricket Injury Prediction and Surveillance by Mobile Application Technology on Smartphones

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**Introduction:** The demands on cricketers are increasing with more matches being played in a shorter period of time with a greater intensity. A ten year report on injury incidence for Australian elite cricketers between the 2000-2011 seasons revealed an injury incidence rate of 17.4%. In the 2009-10 season, 24% of Australian fast bowlers missed matches through injury. Injury rates are even higher in junior cricketers with an injury incidence of 25% or 2.9 injuries per 100 player hours reported. Traditionally, injury surveillance has relied on the use of paper based forms or complex computer software [3], [4]. This makes injury reporting laborious for the staff involved. The purpose of this presentation is to describe a smartphone based mobile application as a means of improving injury surveillance in cricket.

**Methods:** CricketPredict mobile App for the Android platform was developed using Qt SDK (Software Development Kit) as IDE (Integrated Development Environment). C++ was used as the programming language with the Qt framework, which provides us with cross-platform abilities that will allow this app to be ported to other operating systems (iOS, Mac, Windows) in the future. The wireframes (graphic user interface) were developed using Justinmind Prototyper Pro Edition Version (Ver. 6.1.0)

**Results/Findings:** CricketPredict enables recording of injury and training status conveniently and immediately. When an injury is reported automated follow-up questions include site of injury, nature of injury, mechanism of injury, initial treatment, referral and action taken after injury. Direct communication with the player then enables assessment of severity and diagnosis. CricketPredict also allows the coach to maintain and track each player's attendance at matches and training session. Workload data can also be recorded by either the player or coach by recording the number

of balls bowled or played in a day. This is helpful in formulating injury rates and time lost due to injuries. Excessive workload of bowling has been linked to injury and thus the system can generate alerts when a bowler over bowls.

**Outcomes & Significance:** Use of CricketPredict offers a simple, user friendly tool for the coaching or medical staff associated with teams to predict record and report injuries. This system will assist teams to capture injury data with ease thus allowing better understanding of injuries associated with cricket and potentially optimize the performance of such cricketers.

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### Toward a Concussion Assessment Tool in Snowsports: Is the balance assessment component of the SCAT reliable?

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**Introduction:** Currently there is no evidence-based concussion assessment baseline and post-head-impact protocol available for snowsport athletes. The Zurich Consensus statement on Concussion recommended further assessment of the Sport Concussion Assessment Tool 2 (SCAT 2) for validity and reliability as well as recommending that the role of additional balance testing in the assessment protocol be considered. Project aims were to: 1) assess the usefulness of the SCAT2 in informing snowsport athletes about their baseline, pre and post- concussion status; and 2) work towards developing user-friendly and accessible concussion assessment tools building on existing smart phone Apps such as: the "SCAT2" and "Accelerometer Data Pro", that would enhance concussion assessment across all sports.

**Methods:** The project aims were achieved by: determining the degree of correlation of the SCAT2 (including the balance protocol comprising a visual assessment of errors in the tasks, bilateral feet together stance, single leg stance and tandem stance) over two occasions in a snowsport athlete population compared to 2 instrumented balance assessment tools: 1) the inbuilt accelerometers in iPods; and 2) the "gold" standard of postural sway assessment, the static force platform. In 2012, 23 snowsport athletes were recruited from the squads of the New South Wales Institute of Sports and the Olympic Winter Institute, Australia. SCAT2 testing occurred when athletes were undertaking their baseline sport science testing during the Australian 2102 and 2013 winter seasons.

**Results:** Correlation between the SCAT2 over two separate occasions was moderate ( $r=0.58$ ,  $p=0.006$ ). This was mediated by the strong correlation of the sub-category "Symptom Score" while sub-category "Balance Score" did not correlate significantly across test occasions (Pearson's  $r=0.42$ ,  $p=0.054$ ). There were no other significant correlations between measures across the two occasions of testing. Those who had reported a significant head impact history (17.5, SD 2.6 years) were significantly older than the group not reporting a significant head impact (21.5, SD 4.6 years). Two of the instrumented balance test measures, both in the single leg stance protocol, approached a significant difference between the "significant head impact" and "no head impact" groups, warranting further investigation in a larger sample.

#### Conclusion:

- The symptom component of the SCAT2 is reliable over a 12-month period in snowsports athletes.
- The balance test component of the SCAT2, did not achieve a significant correlation over the same time period.
- The SCAT2 tool was not sensitive to differences between participants who had suffered a significant head impact versus those who had not.
- The two instrumented balance assessments approached significance and should be considered for further evaluation in a larger sample of participants.

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### Is there an association between pre-season musculoskeletal screening tests and in-season lower limb injuries in Australian football players?

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**Introduction:** Injuries are common in Australian football (AF) and musculoskeletal (MSK) screening is used to identify predisposing factors for MSK injuries. The aim of this study was to investigate if pre-season screening tests were associated with non-contact lower limb injuries sustained during a regular AF season.

**Methods:** Thirty six AF players (age 21.8 years, range 19-31) from a semi-elite football club completed seven MSK screening tests prior to commencement of the 2014 football season. The MSK screening tests were knee to wall (KTW) for ankle dorsiflexion range of motion, supine passive hip internal rotation, adductor squeeze test at 60° hip flexion, side lying hip abduction and adduction isometric muscle strength, the modified star excursion balance test and triple hop for distance. The triple hop limb symmetry index (THLSI) was also calculated. Time loss injuries were recorded for 16 games throughout the 2014 season. The Mann Whitney U test compared MSK screening data for the injured (I) group with the non-injured (non-I) group.

**Results:** There were a total of 10 lower limb injuries recorded in 16 rounds. The statistically significant MSK screening test results associated with any lower limb injury were right KTW (cm) (I  $X=10.3 \pm 5.01$ , non-I  $X=13.74 \pm 3.41$ ,  $p=0.043$ ) and THLSI (%) (I  $X=0.94 \pm 0.07$ , non-I  $X=1.01 \pm 0.07$ ,  $p=0.034$ ). Right KTW (cm) was associated with hip / groin / thigh injuries (I  $X=5.75 \pm 3.86$ , non-I  $X=13.66 \pm 3.27$ ,  $p=0.003$ ) and right triple hop (m) was associated with knee injuries (I  $X=6.15 \pm 0.28$ , non-I  $X=7.12 \pm 0.5$ ,  $p=0.031$ ).

**Discussion:** Musculoskeletal tests conducted during pre-season were found to be associated with MSK injury at a semi-professional AF level. While the KTW test has established predictive validity, the results of this study suggest the triple hop for distance test may be a useful test for predicting injury and warrants further investigation. If AF clubs conduct preseason MSK screening, the KTW and triple hop for distance tests should be considered for inclusion in the screening protocol.

## Is higher serum cholesterol associated with altered Achilles tendon structure or Achilles tendon pain in the general population?

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**Introduction:** Up to 30% of Achilles tendinopathy presents in non-active individuals and an association between adiposity and tendinopathy has been highlighted. Inactivity and adiposity are both associated with unfavourable serum lipid parameters. Individuals with Achilles tendinopathy have a dyslipidaemic profile and the extreme cholesterol levels seen in familial hypercholesterolaemia are associated with a 6-fold increased lifetime prevalence of Achilles tendon pain (47% versus 7%). It is unknown whether an association exists between lipid parameters and tendon structure in the general population.

**Methods:** Serum lipids and Achilles tendon structure were measured in healthy participants. Lipid parameters included total cholesterol (TC), high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C) and triglycerides (TG). Glucose (GLU) was also measured. Ultrasound tissue characterisation (UTC) was used to quantify Achilles tendon structure; echo-types I (green) and II (blue) were used for analysis. Height, weight and waist circumference were measured. Physical activity level and history of Achilles tendon pain were recorded via questionnaire.

**Results:** The 67 participants recruited included 42 men and 25 women, mean age 42.2±13.2. The mean physical activity level of participants was 113±42 minutes/week. Sixteen participants (24%) reported a history of Achilles tendon pain. There were no statistically significant correlations between echo-types I/II and any of the metabolic parameters – with Spearman's correlation coefficients of .07 ( $p=.57$ ) for TC, .22 ( $p=.08$ ) for HDL, -.43 ( $p=.74$ ) for LDL, -.06 ( $p=0.62$ ) for TG and .22 ( $p=0.08$ ) for GLU.

**Discussion:** This study did not show an association between cholesterol and tendon structure. While there was significant variability in the UTC measured tendon structure, the lipid results were relatively homogenous. For example, TC results were clustered between 4.0 and 6.0mmol/L, suggesting that a vast majority of the participants are fundamentally “normal”. Thus, cholesterol at this level is not correlated with altered tendon structure.

## A comparison of training days lost and injury type for male and female athletes competing at the 2010 Pan Pacific Masters Games

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**Introduction:** It is important to increase participation in master's sports, which represents a vehicle for increased physical activity. However, it is likely that athletes in the master's age group may be more wary of injuries compared to younger populations and if they sustain injury it will be important to know the interruption to training that may compromise physical activity and consequently physical fitness. The aim of the research was to assess if master's athletes suffered injury in preparation and training for the 2010 Pan Pacific Masters Games, Gold Coast, Australia and the impact of injury on training in terms of loss of training days linked with type of injury sustained and gender of the athlete.

**Methods:** 1568 athletes, (731 males: age mean=50.82 years, SD±9.38, range=25-83 and 837 females: age mean=47.63 years, SD±8.41, range=25-79) competing at the 2010 Pan Pacific Masters Games volunteered and completed an online survey regarding injuries received during training within three months prior to the competition. The specific questions related to different types of injuries sustained and number of days lost from training due to injury. Injuries recorded were abrasions/cuts, concussion, contusion/bruising, dehydration, dental injury, dislocation, fracture, inflammation, joint pain, laceration, ligament strain/tear, muscle/tendon tear, muscle pain, puncture wound and sprain. Descriptive statistics and independent t-tests were conducted comparing male and female athletes across injury types with days lost from training.

**Results:** The total injury rate reported for all sports was a low 12.8% ( $n=105$  or 6.7% males and  $n=95$  or 6.1% females) of the 1568 athletes. The most significant injuries in terms of days lost from training linked to gender expressed as means were fracture (female =40.86: males=15), ligament sprain/tear (female=20.27: male= 17.84), muscle/tendon strain (female=13.32: male=13.56), inflammation (female=12.71: male=10.22), joint pain (female=7: male=10.53), sprain (female=9.07: male=7.43) and muscle pain (female=3.24: male=7.13). Abrasion/cuts, concussion (very rare), contusion/bruising, dislocation (very rare), laceration and puncture wound (non-reported) displayed minimal consequences in days lost from training.

**Discussion:** As expected the fractures, ligament sprain/tear, muscle/tendon strain, inflammation, joint pain, sprain and muscle pain were injuries most responsible for days lost from training and female athletes displayed higher prevalence of days lost from fractures, ligament sprain/tear, inflammation and sprain, whereas males higher prevalence for joint sprain and muscle pain. This indicates musculoskeletal problems are predominant with this age group and may suggest some injury prevention strategies based on enhancing musculoskeletal fitness, joint stability, inflammatory control and dynamic movement equilibrium.

## Sports injury surveillance at the Pan Pacific Masters Games 2008 to 2014

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**Background:** According to the Van Mechelen “sequence of prevention” model the collection of injury incidence and severity data is the first step towards establishing effective sports injury prevention strategies. Sports injury surveillance data also assists event organisers with the planning of medical services for future sporting events. This study analysed injury surveillance data collected by Sports Trainers at the Pan Pacific Masters Games (PPMG), a large scale, multi-sport event for older athletes held biennially on the Gold Coast, Australia, to establish basic data about the incidence and types of injuries sustained by older athletes at a multi-day sports event.

**Methods:** Sports Medicine Australia accredited Sports Trainers collected injury surveillance data at the 2008, 2010, 2012 and 2014 PPMG using a standardised Medical Encounter Log, which captured basic information about the injured participants sport, date and time of presentation,

a generalised classification of their presenting injury type or medical condition, and the body part injured. The injury surveillance data was subsequently analysed to identify occasions of service by sport, the type of injury and the body part injured. A secondary analysis of the PPMG data was conducted, comparing data collected using the same system at the 2007, 2009 and 2011 Australian University Games (AUG).

**Results:** Total medical encounters to Sports Trainers ranged from 1715 in 2008 (20.01% of total participants) to 4395 in 2014 (36.21% of total participants). The most common reason for presentation to a Sports Trainer were soft tissue injuries (average 66.52%). Muscle strains accounted for 33.02% of all presentations. Injuries to the lower limb accounted for 65.34% of all presentations. 12.36% of the records submitted by Sports Trainers omitted the "injury type" data point. On average there was a 59% higher rate of attendance to Sports Trainers at the PPMG compared to the AUG (presentations per participant: PPMG 0.330, AUG 0.208).

**Discussion:** Older athletes access medical services at the PPMG at a higher rate than at the AUG. High rates of muscle strains is consistent with other studies comparing injury rates of older athletes with younger participants. Medical encounter data collected by Sports Trainers at the PPMG provides useful information about the incidence of sports related injuries and medical conditions in older athletes at a multi-sport event, however more training of Sports Trainers to improve the validity of data collection may be beneficial.

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## Risk factors for hamstring injury: an updated systematic review and meta-analysis

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**Background:** Hamstring muscle strain injuries are a considerable issue in many sports with a high incidence and risk of re-injury, poor healing responses and prolonged symptoms. Despite the large amount of research that has examined hamstring injury there has been limited improvements in injury and recurrence rates. Studies aimed at the identification of risk factors are common, but the literature is plagued by inconsistent findings, analysis of a wide range of single variables, and contains methodology that does not meet suggested guidelines for hamstring risk factor research. This paper presents a systematic review and meta-analysis of intrinsic and extrinsic risk factors associated with hamstring muscle strain injury.

**Methods:** A search of health databases from inception to September 2014 was undertaken using search terms relating to the hamstring muscle, athlete, pathology, and risk. Citation tracking and reference scanning were also performed. Prospective studies of sports-related hamstring strains that assessed some aspect of risk of occurrence or recurrence were included. Random effects meta-analysis was performed where possible to synthesize the data.

**Results:** Forty-seven studies were included in the study after deletion of duplicates and application of selection criteria. Meta-analysis showed that age, previous history of hamstring injury and quadriceps peak torque were associated with hamstring injury, while other isokinetic strength measure, player anthropometrics and most flexibility measures were not. Qualitative analysis identified some associations with active knee extension, quadriceps flexibility, previous ACL / knee injury, eccentric strength or endurance of hamstring, and ethnicity. Fatigue was implicated as a risk factor by proxy measures of injury timing, match characteristics and interchange rates. Some important interactions between risk factor variables were identified.

**Discussion:** A plethora of potential risk factors have been examined, many in single studies, making it difficult for the clinician and athlete to synthesize this large body of literature and translate the findings into practice. Studies of risk factors in this area have been criticised for using a reductionist model and failing to examine complex interactions between risk factor variables. This review collates the evidence to guide clinical practice, directs future research and addresses the limitations of the current evidence.

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## Injuries can be Prevented in Contact Flag Football!

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**Introduction:** This original prospective cohort study was conducted in an attempt to significantly reduce the incidence and the severity of injuries in an intervention cohort as compared to a two-season historical cohort, and to provide recommendations to the International Federation of Football (IFAF) pertaining to prevention measures to make the game safer.

**Methods:** 1260 amateur male (mean age: 20.4 ± 3.9yrs) and 244 female (mean age: 18.5 ± 1.7 yrs) players participated in the study. Four prevention measures were implemented: The no-pocket rule, self-fitting mouth guards, ankle braces (for those players with recurrent ankle sprains) and an injury treatment information brochure.

All time-loss injuries sustained in game sessions were recorded by the off-the-field medical personnel and followed up by a more detailed phone injury surveillance questionnaire.

**Results:** There was an 54% reduction in the total number of injuries, and a significant reduction in the incidence rate and incidence proportion between the intervention cohort as compared to the historical cohort (P<0.001). There was no statistically significant reduction in the number of injuries in any of the body parts, except for in hand/wrist injuries related to the use of pockets (p<0.001), as well as the severity of mild-moderate injuries (p<0.05).

**Discussion:** This study provided evidence that hand/wrist injuries can be significantly reduced in flag football. Recommendations to the IFAF include strict enforcement of the no-pocket rule, the use of soft headgear, comfortable-fitting ankle braces and mouth guards and additionally, to change game rules concerning blocking.

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**Background:** *Project Energise* is an Australian Heart Foundation funded intervention that targets prolonged occupational sitting in office workers. This study aimed to assess the extent to which real-time prompts and self-monitoring of desk sitting encouraged office workers to sit less and move more.

**Methods:** 92 office workers (mean [SD] age 44[12] years; BMI 28[5] kg/m<sup>2</sup>; 63 men) were recruited to the study from three Brisbane based companies. At baseline (April 2014), and then again at end-intervention (November 2014), participants wore a wrist accelerometer (GENEActiv) for one working week, 24 hours/day. Following baseline, participants identified occupational strategies to 'sit less and move more' at a workshop. Worksites 1&2 (W1 [n=19]; W2 [n=16]) implemented these strategies over five months, as did one group at Worksite 3 (W3A; n=33). Another group at this worksite (W3B; n=24) used strategies in combination with the Sitting Pad and a linked software package that gave real time prompts to break from desk sitting via a traffic light system displayed on the individual worker's computer screen. GENEActiv data were classified into mean percentages of work time spent in sedentary behaviour, and light and moderate-to-vigorous physical activity. Intention-to-treat principles were applied, and mixed method statistical models used to compare differences between and within worksites.

**Results:** Mean (SD) baseline data indicated that participants spent 68(12)% of work time sedentary, and 24(9)% in light and 8(4)% in moderate-to-vigorous intensity physical activity (mean [SD] monitored time of 8.8[1.0] hours/day). Participants in W3B were the most sedentary (74[9]%;  $p < 0.01$ ). Workshops identified 20 sit less and move more strategies (13 orientated towards reducing desk sitting; e.g. *deliver some messages in person rather than always sending emails*). Relative to baseline, end-intervention GENEActiv data indicated small, non-significant reductions in work time sedentary behaviour in W2&W3A (2%; decrease of 12 minutes/day). Intervention effects were significant ( $p < 0.05$ ) and four times greater (8%; decrease of 42 minutes/day) in W1&W3B. All worksite groups displaced these respective sedentary percentages and times to light intensity physical activity.

**Discussion:** The findings of this study identify a range of 'sit less and move more' strategies office workers can utilise. Importantly, the data indicate that using strategies in combination with real-time prompts to break desk sitting may be an effective way of facilitating positive changes in some, but not all worksites. Future studies should investigate why this may be the case.

#### AWARD FINALIST

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**Background:** Online social networks offer considerable potential for delivery of mass-reach, socially-influential health behaviour change interventions. This study aimed to determine the efficacy, engagement and feasibility of an online social networking physical activity intervention delivered via a Facebook application.

**Methods:** 110 adults (mean age 35.6, SD 12.4 y) were recruited online in teams of 3-8 friends. Teams were randomly allocated to receive access to a 50-day online social networking physical activity intervention which included self-monitoring and social elements ("Active Team" Facebook application; n=51 individuals, n=12 teams) or a wait-listed control condition (n=59 individuals, n=13 teams). Assessments were undertaken online at baseline, 8 weeks and 20 weeks. The primary outcome measure was self-reported weekly moderate-to-vigorous physical activity (MVPA). Secondary outcomes were weekly walking, vigorous physical activity time, moderate physical activity time, overall quality of life and mental health quality of life. Analyses were undertaken using random effects mixed modeling, accounting for potential clustering at the team level. Usage statistics were reported descriptively to determine engagement and feasibility.

**Results:** At 8 week follow up, the intervention participants had significantly increased their total weekly MVPA by 135 minutes relative to the control group ( $P = 0.03$ ), due primarily to increases in walking time (155 min/week increase relative to controls;  $P < .001$ ). However, statistical differences between groups for total weekly MVPA and walking time were lost at 20 week follow up. There were no significant changes in vigorous physical activity, nor overall quality of life or mental health quality of life at either time point. High levels of engagement with the intervention, and particularly the self-monitoring features, were observed.

**Discussion:** An online, social networking physical activity intervention can produce sizeable short-term physical activity changes. Future work is needed to determine how to maintain behaviour change in the longer term, how to reach at-need populations, and how to disseminate such interventions on a mass scale.

## AWARD FINALIST

P. Morgan<sup>1\*</sup> • D. Lubans<sup>1</sup> • M. Young<sup>1</sup> • A. Barnes<sup>1</sup> • N. Eather<sup>1</sup> • E. Pollock<sup>1</sup><sup>1</sup>University of Newcastle

**Introduction:** Over 80% of girls do not meet physical activity (PA) recommendations. Although fathers may influence their daughters' PA levels, they often: (i) are less involved with their daughters than mothers and (ii) discount their role in fostering their daughters PA and social-emotional well-being (SEW). The aim of this RCT was to develop and evaluate a program targeting fathers and their daughters to improve: (i) daughter/father PA and (ii) daughter SEW.

**Methods:** Two-arm RCT of 115 fathers (mean [range] age=41.0 [29.3-52.9] years) and their primary school-aged daughters (n=153) who were randomised to: (i) DADEE intervention, or (ii) wait-list control. The 8-week intervention included weekly sessions (theoretical and practical) that developed the daughters' SEW skills (e.g. self-control, resilience) using PA as the medium. Practical sessions involved movement skills, rough-and-tumble play and fitness games. A supplementary home-based program was provided to motivate daughters to practice SEW skills in PA challenges with Dad to earn 'EmPower' cards. Assessments were held at baseline and immediate post-intervention. The two primary outcomes were father and daughter PA levels (7 days pedometry). Daughter SEW was measured with the Strengths and Difficulties Questionnaire [SDQ] and the Devereux Student Strengths Assessment [DESSA]). The quality of the father-daughter relationship was assessed using the Parent Child Relationships Questionnaire. Co-PA and PA parenting practices were measured using validated scales.

**Results:** Intention-to-treat linear mixed models revealed a significant intervention effect for daughter PA ( $p=0.04$ ,  $d=0.32$ ) with DADEE daughters increasing (+1191 steps/day; 95%CI, 631,1751) more than control daughters (+366 steps/day; 95%CI, -168,899). A significant effect was found for fathers ( $p<0.001$ ,  $d=0.43$ ), with DADEE fathers increasing by 1031 steps/day (95%CI, 501,1561) and control fathers decreasing by 309 steps/day (95%CI, -833,216). Significant SEW intervention effects ( $p<0.05$ ) were found for the DESSA social-emotional composite ( $d=0.47$ ) and SDQ pro-social subscale ( $d=0.32$ ), but not for the SDQ emotional subscale ( $p=0.08$ ,  $d=0.24$ ). Significant effects ( $p<0.01$ ) were also found for father-daughter relationship quality ( $d=0.88$  [fathers];  $d=0.45$  [daughters]), co-PA ( $d=0.73$ ), limit setting ( $d=0.43$ ) and monitoring ( $d=0.60$ ). Attendance was 93% and retention 97%. Mean (SD) program satisfaction was 4.9(0.3) for both fathers and daughters (5=excellent).

**Discussion:** This study demonstrated the strong feasibility and positive impact of a PA program specifically targeting fathers and daughters. DADEE improved father/daughter PA levels, co-PA, PA parenting practices, father-daughter relationship quality, and daughter SEW. This was the first study internationally to target the father-daughter relationship as a novel engagement mechanism to improve SEW and PA in girls.

N. Eather<sup>1\*</sup> • P. Morgan<sup>1</sup> • D. Lubans<sup>1</sup><sup>1</sup>The University of Newcastle Australia

**Introduction:** High levels of health-related physical fitness (especially body composition, cardiorespiratory fitness and muscular fitness) are associated with improvements in a range of physical, cognitive and psychological health outcomes. However, physical activity levels decline dramatically during adolescence and global estimates suggest that 80% are not meeting physical activity guidelines, almost 25% of adolescent girls and boys are overweight or obese, and that the majority of overweight youth remain overweight in adulthood. There is clearly a need for researchers to find engaging and novel ways of helping adolescents participate in health-enhancing physical activity. The aim of this study was to evaluate the preliminary efficacy and feasibility of the CrossFit Teens™ resistance training program for improving health-related fitness and resistance training skill competency in adolescents in the school setting.

**Methods:** This assessor-blinded randomized controlled trial was conducted in one secondary school in the Hunter Region, Australia from July-September, 2013. Ninety-six (96) students (age =15.4 (.5) years, 51.5% female) were randomized into intervention (n=51) or control (n= 45) conditions for 8-weeks (60 min. twice per week). Waist circumference, BMI, BMI-Z score (primary outcomes), cardiorespiratory fitness (shuttle-run test), muscular fitness (standing jump, push-up, handgrip, curl-up test), flexibility (sit and reach) and resistance training skill competency, were measured at baseline and immediate post-intervention. Feasibility measures of recruitment, retention, adherence and satisfaction were assessed.

**Results:** Significant group-by-time intervention effects were found for waist circumference [-3.1cm,  $p<0.001$ ], BMI [-1.38 kg/m<sup>2</sup>,  $p<0.001$ ], BMI-Z [-0.5 z-scores,  $p<0.001$ ], sit and reach [+3.0cm,  $p<0.001$ ], standing jump [+0.1m,  $p=0.021$ ] and shuttle run [+10.3 laps,  $p=0.019$ ]. Retention rate was 82.3%. All program sessions were delivered and participants' mean satisfaction scores ranged from 4.2 to 4.6 out of 5.

**Conclusions:** The CrossFit Teens™ program has demonstrated success in improving HRF outcomes in adolescent girls and boys – suggesting that incorporating CrossFit™ training into the Physical Education curriculum in secondary schools may be a safe, effective, and appealing approach to promote physical fitness in adolescents. However, the varied adaptations stimulated in boys and girls participating in the program, imply that different approaches may be needed for boys and girls if targeting identical outcomes in the future. Further research is also needed to establish long term health gains, sustainability in the school setting and impact on physical activity beyond the school setting. In this study, CrossFit Teens™ was shown to be a feasible and efficacious program for improving health-related fitness in adolescents in the school setting.

## AWARD FINALIST

J. Bellamy<sup>1</sup>\*<sup>1</sup>The Children's Hospital Westmead

**Background:** Current research supports the increasing prevalence of obesity in children with intellectual disabilities (ID). Four potential contributing factors have been identified and include: reduced physical activity levels, poor nutrition, medications-induced metabolic abnormalities and lack of parental/guardian awareness. Current exercise interventions targeting obesity management have relied heavily on high supervisor to child ratios in children diagnosed with mild-moderate ID. Small effects have been illustrated through conservative exercise prescription, mainly comprising of such activities as walking groups, treadmill walking and small numbers of resistance-based exercise. This pilot aims to assess the feasibility of a group-based exercise intervention for children with moderate-severe ID in a school-based setting.

**Methods:** 10 students aged between 9-13 years from a School for Special Purposes (SSP) located in South West Sydney completed a 16 week exercise intervention consisting of one 30-minute exercise session per week. Exercise sessions comprised of 60% aerobic, 20% strength and balance, 20% fundamental movement skill (FMS) development. Anthropometry (height, weight, BMI and waist circumference), 6-Minute Walk Test (6-MWT), standing broad jump, sit and reach, single leg balance and the NSW Schools Physical Activity and Nutrition Survey 2010 FMS assessment battery was completed 0, 8 and 16 weeks. Follow up assessment was completed 3-months following completion of the exercise intervention.

**Results:** In our population, 40% of the children were overweight and a further 30% were obese (median BMI of 23.3). Participants attended 74.4% of all 16 sessions offered, with the main reason for non-participation being absenteeism from school. Small groups of 3-5 children per supervisor were achieved by the completion of the intervention. 0% dropout rate with 100% of surveyed parents wishing to re-enrol their child into the program. 50% of teachers reported increased compliance in class following exercise sessions. No significant change was observed in BMI z scores ( $p = .175$ ) or waist circumference ( $p = .241$ ). However, aerobic capacity (as measured through 6-MWT) significantly improved throughout the intervention ( $p = .008$ ; 95% CI), whilst returned to initial baseline at the 3-month follow up assessment time point. FMS increased significantly ( $p = .000$ ) over the course of the intervention.

**Discussion:** Through the use of three main facilitation strategies; FMS development, social interaction and multiple communication pathways, this study supports the feasibility of a group-based school exercise intervention for children with moderate-severe ID. This novel intervention further supported improvements in aerobic capacity, flexibility and FMS development.

M. Vetter<sup>1</sup>\* • H. O'Connor<sup>1</sup> • N. O'Dwyer<sup>2</sup> • Ro. Orr<sup>1</sup><sup>1</sup>The University of Sydney • <sup>2</sup>Charles Sturt University

**Introduction:** The effectiveness of learning while exercising has gained increased attention, particularly as a potential strategy to reduce sedentary time in school children. This study aimed to determine the effectiveness of combining aerobic physical activity (PA) with learning a numeracy skill – the times-tables – in primary school students, compared with a standard classroom approach. Learning times-tables is an important yet challenging skill for primary school students and mastery is known to be essential for future academic achievement in mathematics.

**Methods:** This study was a randomized controlled trial. Grade three students (8-9y) of mixed gender, ethnicity and socioeconomic status from two Australian public schools were randomly allocated to either Playground (P) or Classroom (C) mathematics classes. The six-week, 18-session intervention involved 3×30 minute sessions per week of either P (moderate-vigorous aerobic exercise drills while simultaneously completing maths games to learn the times-tables) or C (seated- activity based maths games similar to P). Pre- and post-assessment of body mass index (BMI), fitness ( $VO_{2peak}$  via the Shuttle Run), general numeracy competence (via National Assessment Program – Literacy and Numeracy [NAPLAN] test), and times-table competence was conducted. Data: mean±SD.

**Results:** Of the 147 participants, 72 were randomized to P. All baseline variables were similar between the groups. After six weeks there were no significant between-group differences in outcomes. However, there was significant within-group improvement for fitness (P: 25.4±3.6 to 27.9±4.3; C: 26.0±4.0 to 28.1±4.8 ml.kg.min<sup>-1</sup> both  $p < 0.0001$ ), times-tables (P: 50.9±31.4 to 70.5±29%; C: 52.5±27.9 to 69.0±25.0% both  $p < 0.0001$ ) and NAPLAN (P: 53.4±19.6 to 58.6±20.1%; C: 54.7±15.4 to 61.1±16.9% both  $p < 0.0001$ ). There were no significant BMI changes within either group.

**Discussion:** Although the P group participated in an additional nine hours of PA across the six weeks, post-intervention outcomes were similar to those achieved in the classroom. Both interventions were well received and demonstrated that learning was not compromised by simultaneously undertaking PA in the playground. Our intervention was short and potentially of insufficient length to produce significant between-group changes. However, since learning was not compromised, the inclusion of 30 minutes of moderate-vigorous aerobic activity within an academic lesson provided an opportunity for students to achieve half the Australian daily PA recommendations (60 minutes moderate-vigorous PA/day). With emerging evidence suggesting that it may also be effective for content requiring memorizing, active learning appears to be a promising approach that simultaneously addresses the major public health issues of childhood obesity and sedentariness.

## AWARD FINALIST

Ro. Orr<sup>1\*</sup> • C. Cocke<sup>1</sup> • J. Dawes<sup>2</sup><sup>1</sup>Bond University • <sup>2</sup>University of Colorado Colorado Springs

**Introduction:** Police cadets must adjust to new occupational physical demands during their initial academy training to transition from civilian life to the tactical athlete lifestyle. These new demands, such as wearing heavy body armour and performing defensive tactics, place new strains on the body and put the cadets at an increased risk of injury. Tactical athletes (like police officers) who are not at an adequate level of physical fitness are more susceptible to injury and are less likely to be able to fulfil the physical requirements of the profession. Therefore, the physical training cadets complete must adequately prepare them for the rigours they will face during their career if they are to limit their risk of injury. The aim of this study was to compare two different styles of physical training programs, one randomised workout style and the other a structured periodised program, on multiple measures of anthropometrics and fitness in police cadets.

**Methods:** Data provided from the Corpus Christi Police Department (USA) on pre- and post-training measures for 4 randomised training classes (n=65, age=28.96±6.34yrs, weight=79.44±18.06kg, lean body mass=63.41±15.45kg) and 1 periodised class (n=25, age=21.76±5.37yrs, weight=83.15.66kg, lean body mass=67.55±11.62kg) of cadets undergoing police training were analysed. The training programs were performed over 6 months. The randomised training group (RTG) incorporated various strength and endurance exercises chosen on the day of training. The periodised training group (PTG) alternated specific phases of training focusing on muscular endurance, hypertrophy, strength, and power. Outcome measures included 3 body anthropometric measures (weight, lean body mass, fat mass), four muscular fitness measures (1RM bench press, push-ups, sit-ups, vertical jump) and 2 metabolic fitness (300m sprint, 2.4km run) measures.

**Results:** Both groups made significant reductions in fat mass, however only the RTG decreased in body weight (change=-1.60±3.38kg; p<.001) and increased in LBM (change=1.59±2.75kg, p<.001). For performance measures, both groups improved in 1RM bench press, push-up repetitions and sit-up repetitions, however only the RTG improved in vertical jump height (change=8.04±5.79cm, p<.001), 300m sprint times (change=-5.25±3.66sec, p<.001), and 2.4 km run times (change=-86±59sec, p<.001).

**Discussion:** Physical training programs can improve the physical fitness of police cadets thereby preparing them for their career duties. A program consisting of randomly selected workout exercises may better improve fitness measures than a specifically structured training program which isolates focus on individual areas of performance. A notable limitation of this study was the lack of injury rates as an outcome measure.

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**Background:** *Shifting Gears* is a joint Australian, State and Territory funded lifestyle initiative that uses smartphone technology to help truck drivers monitor and self-regulate healthy lifestyle choices. Using a random forest activity classifier for wrist-worn accelerometer data, this study examined the workday sedentary (lying [sleeping] or sitting quietly), stationary (sitting with upper limb movement or standing) and movement (walking or running) time of drivers at the baseline, intervention and follow-up phases of the initiative.

**Methods:** Ten long-haul and 34 local-delivery drivers (all men; 47.5±9.8 years; BMI 33.8±6.3 kg/m<sup>2</sup>; waist circumference 113.7±13.3 cm) were offered a free *Jawbone UP* activity tracker and access to an interactive smartphone application (*UP*) that synchronises with the tracker. Drivers virtually connected with researchers and other users, and targeted workday opportunities for sitting less and moving more across five months (April-August 2014). GENEActiv accelerometers were worn (24 hours x 7 days) at three time points (pre and end-intervention, and at two months follow-up), and data from the random forest classifier was used to calculate the mean (SD) proportions of workday sedentary, stationary and movement time. Data were analysed using ANCOVA and intention-to-treat.

**Results:** Eight long-haul and 28 local-delivery drivers (82% of the sample) provided 24-hour GENEActiv data. At baseline, long-haul drivers spent a significantly lower proportion of their day sedentary (38[2]%; difference of 5% [1.2 hours/day]; p<0.05) and a significantly higher percentage stationary (56[2]%; difference of 7% [1.7 hours/day]; p<0.05). Local-delivery drivers accumulated significantly more movement time (8[1]%; difference of 3% [43 minutes/day]; p<0.05). Relative to baseline, no significant changes were found in the mean proportions of time drivers spent sedentary, stationary or moving at end-intervention and follow-up. However, changes in movement time varied from -3% (decrease of 43 minutes/day) to +5% (increase of 1.2 hours/day), and on a case-by-case basis, involvement in the initiative encouraged ten drivers (28% of the GENEActiv sample; 9 local delivery) to increase time spent moving.

**Discussion:** The typical sedentary, stationary and movement patterns of the long-haul and local delivery drivers involved in this study differed. Also, while a minority of local delivery drivers benefited from the initiative, *Shifting Gears* had no overall positive impact on these patterns over a 24-hour workday. The study findings highlight the need for targeted action in sub-groups of drivers, as well as specific analyses of changes in sedentary, stationary and movement patterns relative to shift time.



A. Kountouris<sup>1\*</sup>  
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Lumbar stress bone stress injuries in the posterior aspect of the vertebral arch in the region of the pedicle, pars interarticularis and lamina are common in young athletes involved in sporting activities that are associated with vertical impact forces. They typically, result in long rehabilitation periods and can be missed in the early stage of the bone stress continuum. Early detection and management is important because non-union, ongoing pain and dysfunction is unfortunately a common outcome. An understanding of bone pathophysiology, key clinical features and imaging is important in optimising management.

The management of lumbar bone stress injuries is dependent on the stage of the bone stress continuum, which ranges from early stage bone stress to frank stress fractures. The role of imaging, particularly magnetic resonance imaging is crucial in both, detecting early stage bone stress, and distinguishing between active bone stress injuries and chronic non-united defects.

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**Background:** Despite high levels of fitness and intensive strength training, low back pain (LBP) is common in elite athletes. A recent Australian Football League (AFL) study reported that 30% of players had current LBP and a further 30% had a history of LBP. Incidence of lower limb injuries also remains high in AFL. Of these injuries, hamstring strains show the highest incidence, recurrence and prevalence rates over the last nine years, followed closely by knee, groin and ankle injuries. Efforts to reduce injury rates have largely been directed toward changes in the rules for playing the game and in training regimes. Few studies have examined the relationship between LBP, trunk muscle size and injuries in AFL.

**Methods:** 48 AFL players from one club participated in the project. Data were collected at the start and end of a playing season. Magnetic Resonance Imaging and ultrasound imaging were used to assess muscle size. X-rays were used to assess spinal angles. LBP was assessed via questionnaires. Injury data were provided by the club's medical staff.

**Results:** At the start of the season, 61% of players reported having LBP. Comparison between players with and without LBP showed that (i) those without LBP had larger multifidus muscle size and incurred less injuries,  $p=0.021$  (ii) those with LBP had larger psoas muscles, and incurred more injuries,  $p=0.05$  (iii) those with LBP had larger degrees of thoracic kyphosis,  $p=0.023$ .

**Discussion:** LBP is related to muscle morphology and injuries, and this study confirms the high incidence of LBP in AFL players. Identification of modifiable factors is important to allow development of appropriate intervention programs, which target both LBP and injury prevention. Previous research indicates that LBP does not contribute to a large number of games missed. However, addressing LBP in athletes at the start of the season may prove to be an important injury prevention initiative.

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<sup>1</sup>Menzies Health Institute Queensland, Griffith University

**Background:** Low back pain is common in golfers and changes in golf swing kinematics are frequently cited as contributing factors. To date, most studies investigating the relationship between swing kinematics and injury risk have been conducted in laboratory settings. However, advances in portable motion analysis systems have afforded the opportunity to measure aspects of swing kinematics while playing golf. The present study was conducted using a field-based motion analysis system to determine whether changes in lumbopelvic kinematics occur over a round of golf when using a driver and when putting.

**Methods:** Six amateur golfers (age:  $21.8 \pm 5.4$  years, handicap:  $6.5 \pm 3.1$  strokes) were recruited. Data were collected during shots with driver and when putting during 18 holes of golf from two sensors (L1 and S2) using a wireless 3D motion analysis system (DorsaVi Pty Ltd). Additionally, participants repeated the first hole to enable two repetitions at the same hole to be compared. The position of each sensor at address and range of lumbopelvic movement during driver shots and the first putt for each hole was analysed. Paired t-tests were calculated to determine any significant differences between the first and nineteenth holes.

**Results:** Over the round, during the swing with driver, the upper lumbar spine achieved greater magnitude of right lateral flexion ( $p=0.01$ ). At address position prior to tee-off, the pelvis became more significantly right laterally flexed ( $p=0.04$ ). For putting strokes, there were no significant differences although the pelvis tended to become more laterally flexed to the right ( $p=0.047$ ) towards the end of the round. When repeating driver shot on hole 1 after playing 18 holes, pelvis position was significantly more extended ( $p=0.04$ ) but there was no change in lumbar position. There were no significant differences in lumbar or pelvic position during the putting stroke on hole 1 vs hole 19.

**Discussion:** This study was the first that we are aware of to evaluate lumbopelvic kinematic variables during a round of golf with a system that allows for complete freedom of movement. Findings suggest small but potentially relevant changes occur in lumbopelvic kinematics both at address and during the swing for shots with driver while playing 18 holes. While studies involving larger sample sizes are required, the instrumentation employed was simple, unobtrusive and relatively inexpensive. Findings from future studies conducted in an ecologically valid environment may provide greater insights into mechanisms underpinning the relationship between swing kinematics, golf performance and risk of injury.

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**Background:** Nonspecific chronic low back pain (CLBP) is a common condition associated with significant socioeconomic and healthcare costs. A proposed mechanism for the aetiology and persistence of nonspecific CLBP is dysfunction of the muscles responsible for stability and control of the spine. Core stability programs are designed to retrain optimal trunk muscle recruitment patterns, improve core muscle strength and endurance, and re-establish coordinated functional movements. Although these programs are widely used for rehabilitation, previous systematic reviews have not established the effectiveness of core stability exercise for the treatment of nonspecific CLBP compared with alternative interventions. The aim of this review was to investigate the effect of core stability exercise on pain and disability outcomes in patients with nonspecific CLBP.

**Methods:** Databases were searched for published reports of randomised controlled trials that compared core stability exercise for the treatment of CLBP of nonspecific origin with control or another intervention. Relevant trials were independently reviewed and selected by two authors. Methodological quality of the studies was rated using the PEDro scale. Data were pooled using random-effects meta-analyses to allow for variability between the studies.

**Results:** Eighteen studies ( $n = 1,724$ ) provided post-treatment effect on pain and disability and 7 studies ( $n = 1,125$ ) provided data at six month follow-up. Cohen's  $d$  effect sizes were calculated for both mean pain and disability scores and converted to Hedge's  $g$ . Meta-analysis at post-treatment showed a moderate and significant effect for core stability exercise compared with control or alternative treatment for pain (Hedges  $g = -0.65$ , 95% CI =  $-0.88$  to  $-0.41$ ,  $p < 0.05$ ) and disability (Hedge's  $g = -0.44$ , 95% CI =  $-0.65$  to  $-0.22$ ,  $p < 0.05$ ). At six month follow-up the effects were smaller yet still significant for pain (Hedges  $g = -0.15$ , 95% CI =  $-0.28$  to  $-0.03$ ,  $p < 0.05$ ) and disability (Hedges  $g = -0.19$ , 95% CI =  $-0.33$  to  $-0.04$ ,  $p < 0.05$ ).

**Discussion:** The results of this pooled meta-analysis suggest that in patients with nonspecific CLBP, core stability exercise is superior to other interventions for reducing pain and disability in the short-term. The effect of core stability exercise compared with other treatments reduces with time which may be due to a detraining effect when the participants cease the exercise program. Future research is required to determine the sufficient dosage required to maintain improvements following core stability interventions in order to improve long-term patient outcomes.

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<sup>1</sup>Metro Pain Group

**Background:** Spinal cord stimulation (SCS) of the dorsal root ganglion (DRG) is an emerging neuromodulation technique to treat intractable neuropathic pain conditions. Data from multiple prospective studies and reviews indicate long-term stability of pain relief and good concordance of coverage of discrete pain regions, including areas that are difficult to treat with conventional SCS.

**Objective:** To evaluate outcomes of the first commercially implanted patients in Australia receiving SCS of the DRG.

**Methods:** We assessed 51 consecutive cases in whom SCS of the DRG had been trialed to treat chronic neuropathic pain, post-surgical pain, failed back surgery syndrome, peripheral nerve injury post trauma and other chronic pain conditions. Questionnaires, along with patients' histories were used to evaluate pain (Numerical Rating Scale, NRS), analgesic use, disability (Oswestry Disability Index, ODI) and patient satisfaction. Patients were evaluated at baseline, trial end, and at 3-, 6- and 12-months following implant, or as required per standard of care. The study was IRB approved.

**Results:** Of the temporary trial patients, 35 reported a positive outcome with 29 proceeding to a permanent implant and 6 awaiting implantation. Patients reported significant reductions in mean back pain NRS scores following implantation (baseline  $7.3 \pm 1.2$  vs.  $2.8 \pm 1.4$ ,  $2.5 \pm 1.4$ ,  $2.8 \pm 1.5$  and  $2.5 \pm 1.6$  at end of trial, 3-, 6- and 12-months, respectively; all  $p \leq 0.01$ ). A statistically and clinically significant improvement in the ODI was observed at 6-month follow-up ( $43.7 \pm 14.4$  vs.  $19.0 \pm 4.2$ ,  $p = 0.013$ ). Walking, standing and sitting tolerance times showed a trend towards improvement. Psychological state remained steady, whilst decreases in analgesic use were reported. No major adverse events or complications were observed.

**Conclusion:** Early results in this challenging cohort indicate that SCS of the DRG is a promising technique to treat multiple neuropathic pain conditions and a useful alternative in conditions that do not respond optimally to traditional SCS therapy.

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**Introduction:** The neural control of muscle activity during voluntary concentric and eccentric contractions differs, with the observation that corticospinal excitability and inhibition is lower during eccentric than concentric contractions. Interestingly, strength training one limb results in a substantial increase in strength of the untrained limb; however, it remains unknown what the corticospinal responses are following either eccentric or concentric strength training and how this relates to the cross-education of strength. Therefore, the aim of this study was to determine if eccentric or concentric unilateral strength training differentially modulates corticospinal excitability, inhibition and the cross-transfer of strength.

**Methods:** Changes in contralateral (left limb) concentric strength, eccentric strength, short-interval intracortical inhibition and silent period durations were analysed in groups of young adults who exercised the right wrist flexors with either eccentric ( $N = 9$ ) or concentric ( $N = 9$ ) contractions for 12 sessions over 4 weeks. Control subjects ( $N = 9$ ) did not train.

**Results:** Following training, both groups exhibited a significant strength gain in the trained limb (concentric group increased concentric strength by 64% and eccentric group increased eccentric strength by 62%) and the extent of the cross-transfer of strength was 28% and 47% for the concentric

and eccentric group, respectively, which was different between groups ( $P = 0.031$ ). Transcranial magnetic stimulation revealed that eccentric training reduced intracortical inhibition (37%) and silent period duration (15-27%) compared to concentric training for the untrained limb ( $P = 0.033$ ). There was no change in the control group.

**Discussion:** The results show that eccentric training uniquely modulates corticospinal excitability and inhibition of the untrained limb to a greater extent than concentric training. These findings suggest that unilateral eccentric contractions provide a greater stimulus in cross-education paradigms and should be an integral part of the rehabilitative process following unilateral injury to maximise the response.

### 34 Elite Rugby League Athletes and Tendon Tap / Stretch Reflexes: A Matched Cohort Study

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**Introduction:** A systematic literature review found there is limited research surrounding clinical tendon tap / stretch reflexes in elite athletes. Potential modifying factors were identified which had the possibility to both positively and negatively alter the reflex response in elite athlete populations. In the present study, elite national rugby league (NRL) athletes were compared against age and gender matched control subjects to discover possible differences in reflex responses. A secondary objective was to determine if the length of the player's career, history of injury or a history of surgical intervention had any effect on tendon tap reflexes.

**Methods:** Biceps, triceps, patellar and achilles tendons were assessed using clinical guidelines and results were compared between the athlete ( $n=25$ ) and control ( $n=29$ ) groups. Median reflex responses were compared using the Mann Whitney U test using an alpha level of 0.01. Spearman correlations as well as Wilcoxon matched pair signed rank tests were also employed.

**Results:** Clinically and statistically significant reductions ( $p < 0.005$ ) were found in the biceps, triceps, patella and Achilles reflex responses of the athlete group. A high correlation was found between right and left tendon reflexes, as well as significant negative correlations ( $p = 0.01$ ) between the reflex response of each tendon and the number of years playing professional sport. Biceps reflexes demonstrated the largest difference between groups when compared with the triceps ( $p = 0.004$ ), patella ( $p = 0.001$ ) and achilles ( $p < 0.001$ ) tendons.

**Discussion:** Possible explanations are discussed including central nervous system regulation, muscular adaptation to exercise, passive stretching, and fatigue.

**Conclusion:** Elite rugby league athletes have diminished and absent tendon tap reflexes when compared to an age- and gender-matched control group. Negative correlations were observed between length of playing career and reflex response. Further research is required to elucidate mechanisms contributing to these results and to ensure tendon tap examinations can be used effectively in this population.

### 35 Does playing a sports active video game improve young children's ball skill competence?

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**Background:** Actual and perceived object control (commonly ball) skill proficiency is associated with higher physical activity in children and adolescents. Active video games (AVGs) encourage body movement to control/play the electronic gaming system and therefore provide an opportunity for screen time to become more active. No other study has assessed whether 'playing' video games on the X-Box Kinect improves ball skills. The purpose was to determine whether playing sports AVGs has a positive influence on young children's actual and perceived ball skills.

**Methods:** This study used a two group pre/post experimental design. Thirty-six children aged 6-10 years old from one school were randomly allocated, resulting in 19 intervention children (53% boys; mean age 7.9 years, SD 1.5) and 17 control children (53% boys; mean age 8.0 years, SD 1.2). The Test of Gross Motor Development-3 assessed object control skill. The Pictorial Scale of Perceived Competence for Young Children assessed perceived object control skill. The intervention consisted of six 50-minute lunchtime AVG sessions on the Xbox Kinect. Two to three sport games were chosen for participants to play each session. General linear models with either perceived object control or actual object control skill as the outcome variables were conducted. Model 1 adjusted for intervention status and pre-score of the respective outcome variable. Additional models adjusted for potential confounding variables (sex of child and game at home). Child age was initially adjusted for but removed due to lack of significance.

**Results:** There were no significant differences between control and intervention children for any demographic variables and for actual or perceived skill at baseline. All children were retained at post. There were no significant differences between the control and intervention groups in perceived object control skill competency (Model 1, intervention status (control)  $B = 0.347$ , Model 2 – adjusted for sex,  $B = -1.396$ , Model 3 – adjusted for game at home,  $B = 1.623$ ,  $p > 0.05$  in each). Similarly, there was no significant difference between the control and intervention groups for object control skill competency (Model 1:  $B = 0.671$ , Model 2:  $B = 1.345$ , Model 3:  $B = 0.696$ ,  $p > 0.05$  in each).

**Discussion:** This study found that playing the Xbox Kinect does not significantly influence children's perceived or actual object control skills, suggesting that the utility of the Xbox Kinect for developing perceived and actual object control skill competence is questionable.

### 36 Are the kinematics of the lower limb and trunk captured on a markerless motion capture system comparable to traditional marker-based system?

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**Background:** Three-dimensional motion capture is the gold standard for measuring movement. Reflective marker systems are frequently used but are time consuming for researchers and participants, limiting the number of participants in studies. Markerless systems are quicker to use but it is unclear if they produce comparable data to marker systems. The aim of the project was to compare kinematic data from two motion capture systems – Vicon (marker) and Organic Motion (markerless).

**Methods:** Twenty recreational athletes (10 male, 10 female) aged 22-40 performed two tests: a single joint movement knee flexion test (KFT) and single leg squat (SLS). For KFT athletes stood on one leg and bent the opposite foot up behind them to touch a cord set at the height of their tibial tuberosity, performing 10 consecutive knee flexion movements. In SLS, athletes performed 5 consecutive squats. Thirteen clinically relevant joint angles were chosen for analysis in SLS. Data were analysed with paired t-test if normally distributed and otherwise by Wilcoxon signed rank test. Correlation between systems was analysed with Spearman's correlation coefficient.

**Results:** No significant difference was reported between systems in KFT ( $p=0.33$ ) and in SLS for knee flexion ( $p=0.87$ ), hip adduction ( $p=0.22$ ), pelvic rotation ( $p=0.92$ ), and trunk rotation ( $p=0.63$ ). There were strong correlations ( $r=0.64-0.65$ ) but significant differences in SLS for hip flexion ( $p<0.01$ ), pelvic obliquity ( $p<0.01$ ) and moderate correlations ( $r=0.47-0.56$ ) but significant differences for pelvic tilt ( $p<0.01$ ) and trunk side flexion ( $p<0.01$ ), suggesting systematic error between the systems. The systems' reporting of ankle dorsiflexion ( $p=0.01$ ), knee valgus ( $p=0.02$ ) and rotation ( $p<0.01$ ), hip rotation ( $p=0.03$ ) and trunk flexion ( $p<0.01$ ) were significantly different and were not correlated, suggesting random differences exist for these variables.

**Discussion:** Comparable data were produced in the more controlled KFT. In the more complex SLS test, comparable data were produced in four key kinematic measures. Four measures were moderately correlated but significantly different, indicating a systematic difference in data. Some differences are explained by the way that the two systems define the pelvis. Other differences may be related to error in placing knee alignment devices (KADs) in Vicon and the definition of hip rotation in the Plug in Gait model in Vicon. The markerless system allows for a simple method of capturing kinematic data, but should be used only for within-systems analysis of data.

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### Quadratus Femoris is minimally active in a single leg bridge and single leg squat

#### AWARD FINALIST

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**Background:** Quadratus femoris (QF) is considered an important hip joint stabiliser. Dysfunction of QF has been implicated in a range of lower limb injuries. Our theoretical understanding of the function of QF is predominantly based on radiological, biomechanical and cadaveric studies. Recently, studies using electromyography (EMG) have built on our knowledge of its direction specific action, and its role in walking and running. However, there have been no studies that have evaluated the contribution of QF to commonly prescribed lower limb rehabilitation exercises. The aim of this study was to illustrate and compare the level of activity of QF in two commonly prescribed functional rehabilitation exercises; the single leg (SL) bridge, and SL squat. This knowledge will provide evidence for the utility of these exercises in targeted QF rehabilitation.

**Methods:** Fine-wire EMG electrodes were inserted into the QF of ten healthy young adults (mean age (range) = 23.8 (22-26) years; females=4). Participants performed six repetitions of each exercise, timed to the beat of a metronome. This was repeated for three sets and the order of testing (SL bridge vs SL squat) was randomly assigned. An EMG profile was generated from the middle three repetitions of each set (9 repetitions in total) and averaged across all participants to generate a grand ensemble curve. These were amplitude normalized to percent of maximum voluntary isometric contraction (MVIC), and time normalized to 100 points. The peak and average EMG amplitude was recorded during the eccentric, concentric and total exercise phase, and quantitatively compared between exercises using Wilcoxon signed rank tests ( $\alpha=0.05$ ).

**Results:** The ensemble curves illustrated a single burst activity profile for each exercise. There was a ramped increase in EMG activity for the concentric phase of SL bridge, and the eccentric phase of SL squat. These peaked at the transition into the next phase. There was no significant difference in peak or average amplitude between exercises ( $p>0.05$ ). The median level of activity for both exercises can be considered as minimal ( $< 20\%$  MVIC).

**Discussion:** This is the first study to document the activity of QF in lower limb rehabilitation exercises. The level of activity fell short of the 40% MVIC threshold considered important for strength training. Alternative exercises, or variations of the current exercises should be considered before prescribing a SL bridge or SL squat for targeted QF rehabilitation.

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### Non-invasive brain stimulation increases cortical activation: implications for rehabilitation

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**Introduction:** Emerging evidence suggests that accumulated bouts of non-invasive brain stimulation can improve motor performance with retention lasting months following stimulation. However, improved motor performance following stimulation is not homogenous between all participants and the underlying physiological changes are unclear. This is of particular importance as non-invasive brain stimulation is often employed as a means to induce corticospinal plasticity and further enhance motor performance following neuromuscular injury. Therefore the aim of this study was to examine the accumulative effect of non-invasive brain stimulation on corticospinal excitability, inhibition, cortical activation and strength and whether these responses were regulated by the BDNF polymorphism.

**Methods:** In a randomized cross-over design, changes in strength, corticospinal excitability, inhibition and cortical activation were analysed in 14 young adults who were exposed to four consecutive sessions of anodal tDCS and sham transcranial direct current stimulation (tDCS). Participants also undertook a blood sample for BDNF genotyping (N=13).

**Results:** Following four consecutive sessions of anodal tDCS, there was a significant increase in isometric wrist flexor strength (8% compared to 3% following sham tDCS). Transcranial magnetic stimulation revealed that anodal tDCS increased corticospinal excitability as depicted at multiple points along the stimulus-response curve (32-67%), decreased silent period duration (6-13%) and increased cortical activation (3%) compared to sham tDCS ( $P < 0.05$ ). Interestingly, the magnitude of change in corticospinal excitability and silent period duration was different between genotypes, with Val/Val individuals showing a greater induction of plasticity than those with the BDNF polymorphism.

**Discussion:** The results show that four consecutive sessions of anodal tDCS increases cortical activation which manifests itself as an improvement in strength. Interestingly, the magnitude of change in corticospinal excitability and silent period duration appear to be regulated by the BDNF polymorphism. Collectively, these findings show that accumulative bouts of anodal tDCS induce corticospinal plasticity and improve strength and the BDNF polymorphism differentially regulates the induction of corticospinal plasticity.

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### A simple hip exercise: Hip hitching elicits high levels of deep gluteal muscle activity

AWARD FINALIST

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**Background:** The gluteus medius and minimus muscles are crucial for the lateral stability of the hip joint and pelvis, particularly in unilateral stance. Anatomically, the gluteus minimus and gluteus medius muscles are, respectively, divided into two and three distinct segments. Various exercises are described for rehabilitation of these muscles, however little is known about the effectiveness of these exercises and their ability to elicit muscle activity across all of the segments. Clinically, a hip hitch exercise is presumed to promote high levels of deep gluteal muscle activity since it replicates their role in lateral stability. The aim of this study was to investigate the muscle activity of each segment of gluteus medius and minimus during three functional progressions of a hip hitching exercise.

**Methods:** Intramuscular electrodes recorded electromyographic muscle activity from the anterior (GMinAnt) and posterior (GMinPost) portions of the gluteus minimus and the anterior (GMedAnt), middle (GMedMid) and posterior (GMedPost) portions of gluteus medius muscles in ten healthy women (mean age=60.2 years). Participants completed three sustained (15s) isometric hip exercises: hip hitch, hip hitch with contralateral toe tap and hip hitch with contralateral hip swing and three repetitions of four maximal voluntary isometric contractions (side-lying hip abduction and clam, seated hip external and internal rotation). Average amplitudes were established from the linear envelopes of the middle eight seconds of each exercise, and expressed as a percentage of maximum voluntary isometric contraction. Results were compared between exercises using Friedman's Test and a post-hoc analysis (Wilcoxon Sign Rank test) was performed ( $\alpha=0.05$ ) where appropriate.

**Results:** All exercises showed a high level of gluteal muscle activation (43.85 to 129.88 of %MVIC). The hip hitch was shown to have the highest level of GMinAnt, GMedMid and GMedPost muscle activity; hip hitch with contralateral toe tap elicited highest levels in GMinPost and hip hitch with contralateral hip swing showed highest levels in GMedAnt. Significant differences in segment muscle activity between the exercises existed only for GMinAnt ( $p=0.07$ ). Further post-hoc analysis confirmed significant differences in GMinAnt activity between each of the three exercises.

**Discussion:** A hip hitch and its functional progressions can be used to elicit high levels of muscle activity from the individual constituents of the hip abductor muscles. Clinicians can be confident in prescribing these exercises for hip abductor strengthening, and to assist with functional rehabilitation since the dynamic element reflecting components of walking and stair climbing.

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### Motor skill training and strength training are associated with the same plastic changes in the central nervous system.

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**Introduction:** The neural adaptations that accompany motor skill training are well documented; however whether skill training and strength are associated with the same plastic changes in the central nervous system have yet to be fully determined. Here we sought to address this topic by testing the idea that strength training might share similar mechanisms with some forms of motor skill learning. Therefore, we tested the hypothesis that the magnitude of cortical plasticity would not be different following skill and strength training and that both skill and strength training can propagate the neural mechanisms mediating the cross-transfer of motor function and modulate the ipsilateral primary motor cortex (iM1).

**Methods:** Transcranial magnetic stimulation (TMS) measured baseline corticospinal excitability and short-interval intracortical inhibition in the contralateral primary motor cortex (cM1) and the ipsilateral iM1. Participants completed 4 sets of unilateral training with their dominant arm, either visuomotor tracking, metronome-paced strength training (MPST), self-paced strength training (SPST) or control. Immediately post training, TMS was repeated in both M1s.

**Results:** Corticospinal excitability increased and inhibition was reduced for skill and MPST training from baseline in both M1s. Self-paced strength training and control did not produce any changes in corticospinal excitability and short-interval intracortical inhibition when compared to baseline in both M1s. After training, skill and MPST increased corticospinal excitability and decreased short-interval intracortical inhibition in cM1 compared to SPST and control. Skill and MPST training decreased SICI in iM1 compared to SPST and control post intervention, however, corticospinal excitability in iM1 was not different across groups post training.

**Discussion:** Both skill training and MPST facilitated an increase in corticospinal excitability and released short-interval intracortical inhibition in iM1 and cM1 compared to baseline. Our results suggest that synchronizing to an auditory or a visual cue promotes neural adaptations within the iM1, which is thought to mediate cross transfer. We suggest that these neural responses to strength training, which share similar corticospinal changes to motor learning, might reflect an important process that precedes more long-term neural adaptation that ultimately enhance strength.

## Energetic and metabolic power demands of interchange and full-match players within National Rugby League match-play

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**Background:** Mechanical time-motion models based upon running velocity have estimated the energetic demands of field-based team sports. Little, however, is known about how full-match and interchange players distribute their energetic demands throughout match-play. The purpose therefore is to describe and compare the metabolic demands of rugby league for interchange and full-match players.

**Methods:** Eighteen elite rugby league players participated in this study. A time-motion model was used to estimate the energy expenditure and metabolic demands of rugby league match-play utilising Global Positioning System (GPS) technology. This approach uses a player's GPS velocity-time curve to estimate the positive/negative mechanical work done by the centre of mass in the horizontal/vertical planes, by the swinging-limbs and to overcome air-resistance. It's assumed the sum of these components is the total mechanical-work done due to locomotor demands. Players were categorized into positional groups: outside backs (OB), adjustables (ADJ), wide-running forwards (WRF) and hit-up forwards (HUF). Players were further categorized into full-match or interchange players. Match-play demands were enumerated by match time (min), relative distance ( $\text{m}\cdot\text{min}^{-1}$ ), acceleration/deceleration counts in moderate, high and very high zones ( $\text{n}\cdot\text{min}^{-1}$ ), energy expenditure ( $\text{kJ}\cdot\text{kg}^{-1}$ ), mean power ( $\text{W}\cdot\text{kg}^{-1}$ ), anaerobic index (arbitrary-unit) and equivalent distance (m).

**Results:** OB were excluded from analysis due to 0 interchange files. Interchange WRF covered a 33.6% greater distance of high-intensity running than full-match WRF ( $20.3\pm 11.0$  vs  $15.2\pm 5.3$   $\text{m}\cdot\text{min}^{-1}$ ,  $p=0.025$ ). Full-match WRF expended greater energy per match ( $43.1\pm 6.1$   $\text{kJ}\cdot\text{kg}^{-1}$ ) than interchange WRF ( $28.6\pm 7.5$   $\text{kJ}\cdot\text{kg}^{-1}$ ,  $p\leq 0.001$ ). Interchange WRF produced a mean power 7.4% greater ( $9.3\pm 0.7$  vs  $8.9\pm .5$ ,  $p=0.003$ ), and a significantly higher anaerobic index ( $p=0.016$ ). Full-match ADJ expended 94.8% more energy ( $p\leq 0.001$ ) and covered a 90.5% greater distance ( $p\leq 0.001$ ) than interchange ADJ. Full-match ADJ performed more moderate accelerations (10.1%,  $p=0.014$ ) and decelerations (7.6%,  $p=0.017$ ), whilst also producing a higher anaerobic index ( $0.832\pm 0.042$  vs  $0.358\pm 0.056$ ). Full-match ADJ covered a greater distance at high-intensity running/minute ( $19.3\pm 5.6$  vs  $14.6\pm 7.3$   $\text{m}\cdot\text{min}^{-1}$ ,  $p=0.031$ ). Interchange and full-match HUF performed 11.5  $\text{m}\cdot\text{min}^{-1}$  of high-intensity running/minute. Full-match HUF expended greater energy than interchange HUF ( $36.6\pm 15.6$  vs  $24.0\pm 7.6$   $\text{kJ}\cdot\text{kg}^{-1}$ ). Interchange HUF produced a higher anaerobic index than full-match HUF ( $0.310\pm 0.043$  vs  $0.308\pm 0.017$ ).

**Conclusion:** Differing metabolic demands were identified for interchange and full-match players across positional groups, suggesting specific conditioning drills are needed to model the differing energetic demands of match-play. These differing demands suggest the interchanging of the hooker (ADJ) may be an advantageous strategy in maintaining intensity around the ruck and influencing match outcome.

## Strength and architectural risk factors for hamstring strain injury in elite Australian soccer: A prospective cohort study

### AWARD FINALIST

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**Background:** The Nordic hamstring exercise (NHE) reduces the risk of hamstring strain injury (HSI). Eccentric weakness is a risk factor for a future HSI in elite AFL, however it this has not been investigated in elite soccer. Retrospective studies have shown that biceps femoris long head (BFH) fascicle lengths are shorter in previously injured a BFH compared to uninjured hamstrings. However it is unknown if short BFH fascicle length or low levels of strength during the NHE increases HSI risk in elite soccer.

**Methods:** Elite Australian soccer players ( $n=152$ ) from eight teams in the elite Australian soccer competition participated in this prospective cohort study during the 2014/15 season. At the start of preseason, eccentric strength during the NHE, prone knee flexor maximal voluntary isometric contraction (MVIC) strength as well as BFH architectural characteristics were measured. Previous injury history details and details pertaining to prospective HSIs were provided by the club medical staff.

**Results:** When measured at the beginning of preseason, short BFH fascicle lengths increased the risk of a subsequent HSI 4.1 fold ( $p<0.001$ ). Low levels of eccentric strength during the NHE also increased the risk of a future HSI by 2.8 times ( $p=0.0162$ ). MVIC measures of knee flexor strength did not significantly impact future HSI risk. Multivariate logistic regression revealed an interaction between BFH fascicle length, increasing age and previous HSI leading to an increased risk of HSI.

**Discussion:** Short BFH fascicle length and eccentric knee flexor weakness increases the risk of HSI in elite Australian soccer players and this effect is magnified in older athletes and those with a previous HSI. This evidence suggests that a combination of both modifiable risk factors (BFH fascicle length and eccentric strength) can offset the risk caused by non-modifiable factors such as increased age and previous injury.

## Hamstring injury mechanism is important when considering timing of return to football.

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**Background:** Return to play timing following hamstring strain is a relevant metric for sports medicine personnel, athletes and teams. The ability to predict the likely injury duration has significance for planning rehabilitation and setting expectations for the athlete and coach. As such, the pursuit of variables that may provide return to play timing information is fervent. Injury characteristics on MRI and clinical assessment of injury severity are commonly explored as predictors with mixed findings. A mechanism of injury where the hamstring is on stretch has been shown to result in longer return to play in soccer players and track athletes, but has not been examined in football players. The aim of the current study was to determine if the mechanism of hamstring injury could predict the location of injury or the time to return to football.

**Methods:** The mechanism of injury for 91 hamstring muscles strains in the Australian Football League were examined and the relationship between the mechanism and resultant location of the injury in the muscle and time to return to play were assessed. Risk ratios were calculated.

**Results:** Most strains occurred during high speed running (24%) or when combining running with lumbar flexion (16.5%). A number of injuries occurred with acceleration (8.8%) and no specific mechanism was reported in 17.6% of cases. There was no clear relationship between mechanism of injury and resultant location of injury within the muscle. The mean return to playing time was 25 days, with the majority of players (57%) returning to play at 21 days and 20% returning to play at 14 days. Players who sustained an acceleration injury were 8.8 times ( $p = 0.04$ ) more likely to play more than 25 days following the injury. Comparatively, where no specific mechanism of injury could be described, the players were almost 8 times more likely ( $RR = 7.96$ ,  $p = 0.03$ ) to return to play before 25 days. The location of injury failed to statistically predict the timing of return to play, although 4 of the 5 muscles that resulted in greater than 60 lost days were located in the biceps femoris belly

**Discussion:** Although the mechanism of injury did not predict the location of the hamstring muscle strain it could be useful for therapists to understand the injury mechanism for predicting return to sport.

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## A pre-season training camp alters sleep behaviour and quality but not quantity in elite Australian Rules football players.

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**Introduction:** Travel and environmental changes can be detrimental to sleep quality (efficiency) and quantity (time), which may negatively impact on recovery and subsequent performance in elite athletes. The purpose of this investigation was to assess the effect of a pre-season training camp on the sleep characteristics of elite Australian Rules football (ARF) players.

**Methods:** Wrist-watch actigraphy was used to objectively measure the time in bed (TIB), total sleep time (TST), sleep efficiency (SE) and wake after sleep onset (WASO) of 19 professional ARF players (Age;  $22.1 \pm 3.5$  y, Height;  $185.4 \pm 7.6$  cm, Mass;  $83.3 \pm 7.8$  kg) across two 8-day periods of Baseline and Camp consisting of 5 training and 3 recovery days in each period. Session-RPE was collected following exercise and used to quantify training load. Individual and group (camp and baseline) data (mean  $\pm$  SD) was analysed using repeated measures ANOVA to determine whether mean differences existed for objective sleep, training load and environmental conditions between baseline and camp. Statistical significance was set to  $p = 0.0125$  via Bonferroni correction. Pearson correlation coefficients, controlling for repeated observations on players, were used to assess the relationship between changes in individual sleep characteristics of camp and baseline values.

**Results:** Participants displayed significantly increased ( $p < 0.001$ ) TIB on camp compared to baseline ( $531 \pm 45$  min vs  $497 \pm 56$  min), without significant ( $p = 0.846$ ) increases in TST ( $418 \pm 50$  min vs  $419 \pm 50$  min). On camp, WASO was significantly ( $p < 0.001$ ) increased compared to baseline ( $96.0 \pm 42.3$  min vs  $69.0 \pm 35.3$  min), contributing to a significant reduction ( $p < 0.001$ ) in SE ( $79.0 \pm 8.1$  % vs  $84.7 \pm 7.3$  %). Individual changes in sleep behaviour expressed as percentage-change from baseline found a strong negative correlation for TIB ( $r = -0.75$ ), moderate negative correlation for SE ( $r = -0.46$ ), strong negative correlation for WASO ( $r = -0.72$ ), and no correlation for TST ( $r = 0.09$ ). Whilst the temperature on camp was significantly ( $p < 0.001$ ) hotter than baseline ( $29.0 \pm 1.7$  °C vs  $23.6 \pm 4.4$  °C), mean daily training load was similar between baseline and camp ( $440 \pm 502$  AU vs  $396 \pm 393$  AU).

**Discussion:** A training camp environment affected the sleeping behaviours of elite Australian Rules footballers such that athletes spent significantly longer in bed without any additional benefits of increased sleep quantity, therefore, compromising sleep quality. At the individual level, those with higher sleep efficiency at baseline experienced greater reductions in sleep efficiency on camp. This emphasises the importance of individualised interventions for elite athletes in team sports when travelling or changing environments.

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## Effect of defensive pressure on international female rugby sevens skill execution

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**Introduction:** Rugby training drills provide players with the opportunity to perform the technical and tactical skills essential to match play. The development of technical abilities along with tactical awareness during training drills needs to consider appropriate constraints in the learning environment. One of the most important constraints on a team's performance is the level of defensive pressure. To date there is no data available on the effects of defensive pressure for rugby sevens training drills. Therefore, the aim of the present study was to determine the effects of the level of defensive pressure (no defence, uncontested defence or contested defence) on the frequency and accuracy of attacking skills for international female rugby sevens players during training drills.

**Methods:** Performance analysis was conducted on six different game-simulation drills with a total of 50 training drills analysed during the 2012 – 2013 rugby sevens season. Training drills were recorded using a video camera and only the attacking team's performance was analysed. Game-simulation drills were performed using the whole field and had a focus on developing particular skills or situations of match play with ball movement and team tactics. Specific game-simulation drills included rucks, penalties, restarts, set piece, running patterns and team play. Skill execution outcomes included pass type, pass accuracy, catching, evasive moves and line breaks.

**Results:** Defensive pressure had a significant effect on pass type, evasive moves and line breaks ( $p < 0.05$ ), but no significant effect on the catching ability of players or pass accuracy ( $p > 0.05$ ). A cut-out pass (standard residual (SR) = 3.3) and dummy pass (SR = 2.3) was more likely to happen during uncontested defence, whereas offloads (SR = 9.6), swerves (SR = 2.5) and line breaks (SR = 4.7) were more likely to occur during contested defence.

**Discussion:** Previous research indicates that increased defensive pressure results in acute decreases in ball accuracy of the attacking player during soccer crosses. The present study supported the effects of defensive pressure altering the frequency of pass type, evasive moves and line breaks. However, the accuracy of passes and catching ability of rugby sevens players was not affected by defensive pressure. As cut-out and dummy passes are often required to break the line and score tries in elite sevens, coaches should progressively overload the degree of defensive pressure during training and alter the constraints when required to encourage the performance of these higher risk passes under full defensive pressure.

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## Metabolic power and energetic costs of elite Rugby League match-play

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**Background:** Mechanical time-motion models based on running velocity have estimated the energy demands of field-based team sports. Such analyses have enhanced the understanding of the metabolic loads of match-play and aided in player preparation. The purpose of this study therefore is to describe the metabolic demands of different playing positions in elite rugby league match-play.

**Methods:** A running based time-motion model was utilised to estimate the energy expenditure and metabolic demands of 18 elite rugby league players using 15Hz Global Positioning System (GPS) units. Briefly, this model uses a player's GPS velocity-time curve to estimate the positive/negative mechanical work done by the centre of mass in the horizontal/vertical planes, by the swinging-limbs and to overcome air-resistance. It is assumed that the sum of these components is the total mechanical-work done due to locomotor demands. Players were categorized into positional groups: outside backs (OB), adjustables (ADJ), wide-running forwards (WRF) and hit-up forwards (HUF). Game demands were quantified by match time (min), relative distance (m.min<sup>-1</sup>), energy expenditure (kJ.kg<sup>-1</sup>), mean power (W.kg<sup>-1</sup>), anaerobic index (arbitrary-unit) and equivalent distance (m).

**Results:** OB (62.2±27.0 min) spent more (p<0.001) time on field than HUF (46.5±15.9 min) and WRF (59.1±20.9 min). OB expended the greatest total energy (40.1±5.0 kJ.kg<sup>-1</sup>) per match, 8.1%, 26.6% and 61.9% greater energy than ADJ, WRF and HUF (p<0.001), respectively. HUF covered 13.7% greater distance per minute of match-play than OB (p<0.001), but 8.2% less distance per minute than ADJ (p<0.001), with no difference between HUF and WRF (90.5±5.0 vs 90.4±6.1). ADJ attained an anaerobic index 19.7% higher than HUF (p=0.001) and 43.2% higher than OB (p<0.001). WRF attained an anaerobic index 32.8% higher than OB (p<0.001) and 11% higher than HUF. Mean power of ADJ was higher than all other groups (OB: 28.8%, HUF: 12.4% and WRF: 8.7%) (p<0.001). HUF attained the lowest equivalent distance, 37.9% and 35.2% lower than OB (p=0.001) and ADJ, respectively.

**Conclusion:** Energetic indices identified differing metabolic demands for all positional groups, suggesting positional-specific conditioning drills are required to model the energetic demands of match-play. For example, HUF and ADJ require programs based upon accelerated running whilst WRF and OB require additional high-speed training. GPS-modelled energetic indices could be integrated into the routine monitoring of athletes to provide valuable data on the physiological demands of match-play. Additionally on-field metabolic loads can be equated with ergometer based exercise, allowing sports scientists to maintain aerobic capacities during the rehabilitation of athletes.

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## Effects of a newly implemented self-report measure on athlete self-regulation

AWARD FINALIST

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**Introduction:** In order to achieve long-term performance goals, the ability of an athlete to self-regulate their behaviour is essential. Self-regulation is a cyclic process of performing, evaluating, and adjusting subsequent behaviours to ultimately improve performance. Self-report measures, such as those already widely used in high-performance sports, theoretically have the capacity to facilitate self-regulation. The purpose of the present study was to investigate this theoretical benefit by observing the effect of a newly implemented athlete self-report measure (ASRM) on an athlete's ability to self-regulate, as reflected by the factors of mindfulness, satisfaction, motivation, and confidence.

**Methods:** Athletes (n=193, 117 male, 76 female) had access to an ASRM for 16 weeks and completed an online survey at baseline, weeks 4, 8, and 16. Generalised estimating equations were used to evaluate the associations between ASRM compliance and outcome measures. Further analysis examined differences in effects between athlete expertise, individual and team sports, and whether support was provided by a coach or sports program.

**Results:** Compared to baseline, satisfaction (p<0.001) and intrinsic motivation (p<0.001) decreased at week 4, although had recovered by week 8. Confidence was improved at weeks 4 (p=0.034), 8 (p=0.004), and 16 (p=0.021). These responses were more favourable for expert athletes, and individual sport athletes who were using an ASRM without support.

**Discussion:** Self-report measures theoretically increase an athlete's awareness of their behaviours. An incongruity between actual and ideal behaviours may have prompted initial dissatisfaction, and the necessary stimulus to promote improved future behaviours. An improvement in confidence, with or without improvements in the complete self-regulatory process, is an important and valuable contribution of ASRM use to athletic preparation and performance. Expert athletes likely responded more favourably initially due to pre-existing self-regulatory skills, however this advantage was negated by week 8. The presence of others, as in a team sport environment, may debilitate self-regulatory efforts. Hence it is important that both the athlete and sports program invest effort in establishing an environment which fosters ASRM use for self-regulation.

**Conclusion:** Findings suggest that an ASRM may be useful to facilitate self-regulation, although athlete's sport setting, and to a lesser extent expertise, appear to influence their efficacy.

## AWARD FINALIST

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**Background:** Individuals with a unilateral hamstring strain injury (HSI) history possess shorter biceps femoris long head (BFH) fascicle lengths on their previously injured limb compared to the contralateral uninjured limb. The purpose of this study was to determine i) the fascicle length adaptations of the BFH following either a concentric or eccentric resistance training intervention; ii) the time course of adaptation during an intervention and following a period of de-training.

**Methods:** Participants in this randomised control trial (control [n=28], concentric training group [n=14], eccentric training group [n=14], males) completed a 4-week control period, followed by 6-weeks of either concentric or eccentric only knee flexor training on an isokinetic dynamometer followed by a 28 day detraining period. Fascicle length of the BFH was assessed at rest and during graded isometric contractions utilising two-dimensional ultrasonography at 28 days pre baseline, baseline, day 14, 21 and 42 of the intervention and then again following the 28 day de-training period.

**Results:** BFH fascicle length was significantly longer in the eccentric training group ( $p < 0.05$ ,  $d$  range: 2.65 to 2.98) and shorter in the concentric training group ( $p < 0.05$ ,  $d$  range: -1.62 to -0.96) after 14 days of training compared to baseline at all intensities. Following the 28 day de-training period, BFH fascicle length was significantly reduced in the eccentric training group at all contraction intensities compared to the end of the intervention ( $p < 0.05$ ,  $d$  range: -1.73 to -1.55). There were no significant changes in the concentric training group following the de-training period.

**Discussion:** These data indicate that BFH architectural alterations to resistance training interventions are rapid and contraction mode specific. Following a period of de-training, eccentrically trained individuals will return to baseline values of fascicle length. These findings have implications for HSI rehabilitation and prevention practices to consider architectural adaptations following interventions.

W. Brown<sup>1</sup><sup>1</sup>University of Queensland)

**Introduction:** One aspect of physical activity epidemiology focuses on relationships between behaviours (physical activity and sitting) and health outcomes. The Australian physical activity and sedentary behaviour guidelines for adults recommend moderate or vigorous activity, muscle strengthening activities, and minimisation/breaking up of sitting time. There is no recommendation on frequency or duration of individual activity bouts, on type of activity, or on the relative benefits of moderate and vigorous intensity activities.

**The symposium:** In this interactive symposium, which will comprise a series of short 'question and answer' presentations and discussions, (rather than a series of short 'papers') we will review the sources of the evidence that underpin the guidelines, with updates from recent meta-analyses, and clarification of why there are no specific frequency or duration recommendations. Information about current patterns of physical activity (ie walking, moderate and vigorous intensity) will be presented, using data from several different national and regional Australian population based samples. Relationships between different types of activity with health outcomes will then be considered. Examples of the type of questions to be considered include: "Can 'just walking' be beneficial?", "Are there additional benefits from vigorous exercise?", "Are there health benefits from specific forms of activity?"

**Conclusion:** The symposium will conclude by considering gaps in the evidence, in order to develop future research strategies, and to encourage new collaborations so that important questions can be answered using existing datasets.

S. Mayes<sup>1\*</sup><sup>1</sup>The Australian Ballet

Posterior impingement syndrome (PIS) of the ankle is the most common injury sustained by professional ballet dancers. Repetitive, full plantar flexion of the ankle results in compression and shearing of the posterior ankle and subtalar joint structures. The presence of an os trigonum does not always correspond to symptoms as soft-tissue impingement is often the source of pain. Misdiagnosis may occur as PIS can present similarly to Achilles tendinopathy. Subtalar joint dysfunction is often an underlying source of posterior ankle pain and needs to be addressed. With early modification of activity, manual treatments, and rehabilitation it is uncommon that dancers in The Australian Ballet have required extended periods of time off. In protracted cases, cortisone injection followed by a graduated return to full capacity has been successful. Surgery has rarely been necessary. This presentation will address the key clinical considerations for successful management of PIS.

## AWARD FINALIST

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**Introduction:** Lower limb overuse injuries related to training are common in people who participate in regular physical activity. Foot orthoses are frequently used for the prevention of such injuries but evidence for their effectiveness is limited. The primary aim of this study is to determine if foot orthoses reduce the incidence of lower limb overuse injuries in naval recruits undertaking 11 weeks of basic training.

**Methods:** This study was a participant and assessor blinded, parallel-group, randomised controlled trial. The trial recruited 306 participants undertaking 11 weeks of basic training at the Royal Australian Navy Recruit School, Cerberus, Victoria, Australia. Participants were randomised to a control group (flat insole, n=153) or an intervention group (prefabricated foot orthosis, n=153). Over the 11 weeks of basic training, participants documented the presence and location of pain on pain drawings in their weekly self-report diaries. At an exit interview in week 11, the diagnosis of medial tibial stress syndrome, patellofemoral pain, Achilles tendinopathy, and plantar fasciitis/plantar heel pain was determined by clinical assessment. The end-point for each participant was the completion of 11 weeks of basic training. The primary outcome measure was the combined incidence of four lower limb injuries (medial tibial stress syndrome, patellofemoral pain, Achilles tendinopathy, and plantar fasciitis/plantar heel pain) which are common among defence members. Secondary outcome measures include: (i) overall incidence of lower limb pain, (ii) severity of lower limb pain, (iii) time to injury, (iv) time to drop-out from injury, (v) adverse events, (vi) number of lost training days, (vii) shoe comfort, and (viii) general health status. Data were analysed using the intention to treat principle.

**Results:** Data collection started in January 2015 and will be completed in August 2015. Results will be available at this time.

**Discussion:** This randomised controlled trial will evaluate the effectiveness of foot orthoses for the prevention of lower limb overuse injuries in naval recruits. The findings of this trial will provide best available evidence on this topic.

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**Introduction:** Exercise related leg pain (ERLP) is a lower limb overuse condition commonly encountered in running populations. Contributing risk factors that have been reported include female gender, history of ERLP, body mass index and vertical foot mobility. Interventions targeted to address modifiable factors, such as vertical foot mobility, may have potential in the prevention and management of ERLP. The aim of this study was to compare the effect of rigid and elastic taping on foot posture and mobility in females with ERLP.

**Methods:** Twelve females with ERLP walked for ten minutes under three conditions: barefoot, rigid tape and elastic tape. All participants walked barefoot followed by the two tape conditions, which were randomized in order of application. A two-minute washout walk was provided between tape conditions. After each walk measurements of foot posture and vertical foot mobility were obtained. Perceived comfort of each condition was obtained using a 100mm visual analogue scale (VAS) and participants ranked the most comfortable condition. To ensure there was no carryover effect of the first tape condition, paired t-tests between the barefoot and washout walks were performed. To evaluate differences between conditions a series of one-way repeated measure ANOVAs were performed, followed by pairwise comparisons with Bonferroni adjustment. An alpha level of 0.05 was set for all comparisons.

**Results:** Both rigid and elastic tape increased weight bearing arch height ( $p < 0.001$ ), however the increase was significantly greater in the elastic tape condition ( $p = 0.019$ ). Elastic tape, but not rigid tape, increased non-weight bearing arch height ( $p = 0.004$ ) and the difference between tape conditions was significant ( $p = 0.005$ ). Rigid tape, but not elastic tape, reduced vertical mobility ( $p = 0.026$ ) and the difference between tape conditions was significant ( $p = 0.015$ ). There were no differences observed in comfort VAS scores ( $p > 0.05$ ) however the condition ranked most comfortable was barefoot for 45.5%, elastic tape for 45.5% and rigid tape for 9.1% of participants.

**Discussion:** Clinicians should consider the desired biomechanical effect and comfort in the selection of tape interventions. Whilst both tapes altered foot posture, only rigid tape reduced vertical foot mobility, a reported risk factor for ERLP. Comfort VAS scores appear comparable among tape conditions, however a higher percentage of participants ranked the elastic tape as the most comfortable condition. Further research is required to evaluate the efficacy of rigid and elastic tape intervention on pain and function in ERLP.

## AWARD FINALIST

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**Background:** The use of custom foot orthotics has been shown to improve short- and long-term pain in patients suffering from plantar heel pain. Despite such positive results, typically, in clinical trials of orthotics, the device has not been customised to the individual and has been worn in the footwear of the participant and not in standardised shoes. The aim of this study was to investigate the effect of custom foot orthotics placed in standardised shoes on first-step pain compared to the effects experienced wearing the same shoes without orthotics or no treatment over a time-period of 12 weeks.

**Methods:** A parallel 3-arm randomised controlled trial with concealed allocation and blinding of participants and assessors was used. An *a priori* sample size calculation revealed a required sample size of 60 subjects with clinical and ultrasound diagnosed plantar heel pain (Power = 0.80, alpha = 0.05). The 3-arms of the trial were defined as control (no treatment), shod (new athletic shoes [ASICS Nimbus 15, ASICS, Japan]) and orthotic (custom foot orthotics + new athletic shoes). Participants were randomly allocated to an experimental group using computer generated allocation sequence, and recorded first-step pain using a 100 mm visual analogue scale. A mixed model with time and group treated as factors and subjects designated as random effects was used to analyse the data.

**Results:** A significant main effect of group and time was identified ( $p < 0.05$ ). Over the first four weeks of the trial, there was a large effect of orthotic on first-step pain compared to the control group (MD = 20.9 [9.5 – 34.0] mm,  $p = 0.002$ , ES = 0.820). No differences were identified between the shod and control groups ( $p > 0.05$ ). At 12-weeks, there was a moderate effect of orthotic on first-step pain compared to both the shod (MD = 17.4 [7.8 – 37.4] mm,  $p < 0.001$ , ES = 0.394) and control groups (MD = 24.3 [4.3 – 30.5] mm,  $p = 0.01$ , ES = 0.675). No significant effects of condition were identified between the 4-week and 12-week trial time points ( $p > 0.05$ ).

**Discussion:** The use of custom foot orthotics and new footwear provides a significant improvement in first-step pain over that experienced with new shoes only or no treatment when reviewed at 12-weeks. Although custom foot orthotics did not initially provide a significant reduction in first-step pain compared to just wearing new shoes, a continued gradual improvement throughout the trial resulted in significant improvements in first-step result as a direct result of the orthotic.

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### Flip-flop footwear with a moulded foot-bed for the treatment of foot pain: A randomised controlled trial

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**Background:** Foot pain affects up to 1 in 5 adults and is known to adversely affect activities of daily living and health related quality of life.

Orthopaedic footwear interventions are used as a conservative treatment for foot pain, although compliance is often low due to the perception of poor comfort and unattractiveness of the footwear. Flip-flop style footwear has not been considered as a treatment modality for foot pain as it is believed to provide less support, protection, cushioning and motion control compared to closed-in shoes. The introduction of new design features in flip flops such as moulded foot-beds, increased sole thickness and a heel-to-forefoot slope has provided a potential mechanism to achieve some of the functionality of closed-in shoes. Despite the popularity of flip-flop footwear, these design improvements have not been tested to ascertain their effect on foot pain and function. This study investigated the efficacy of flip-flop style footwear with a moulded foot-bed in reducing foot pain, improving foot function and perception of general foot health and to determine the perceived comfort of the test footwear compared to participant's usual footwear.

**Methods:** Participants with current foot pain which prevents them from doing at least one of their normal activities were randomised into an intervention group (n=54) that received the test footwear and footwear education or a control group that received footwear education only (n=54). Participants were surveyed at baseline and at 12 weeks to determine their foot pain and foot function. The intervention group also completed a daily footwear use diary and a questionnaire relating to the perceived comfort of the intervention footwear.

**Results:** The intervention group showed a significant change in mean score in the primary outcome measures of both pain and function. The change for the Visual Analogue Pain Scale (-9.37mm,  $p < 0.01$ ) and the Foot Health Status Questionnaire domain of foot function (8.36 points,  $p < 0.01$ ) were clinically significant based on validated minimal important differences for these assessment tools. The footwear was well tolerated by the participants in the intervention group with high comfort levels reported.

**Discussion:** To our knowledge this is the first study to show that specialised flip-flop footwear can have a clinically significant effect on foot pain, function and perceived foot health. Features of the test flip-flop such as a moulded foot-bed, anterior and posterior sole bevel and open style may be contributing factors to the reduction in foot pain and function.

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### Resistance training can reverse sarcopenia in older foot muscles

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**Introduction:** Poor toe function has been strongly associated with atrophy and weakness of the foot muscles. We have previously demonstrated that reductions in toe flexor strength are independent contributors to falls in older people. Several studies have found that the foot muscles can positively respond to resistance training in younger adults. However, training studies in older adults are sparse and have been limited by the training programs being non-progressive and/or did not target the intrinsic foot muscles. Therefore, the purpose of our study was to investigate whether a progressive resistance training program, focused specifically on the foot muscles, could improve toe flexor strength in older people.

**Methods:** After baseline testing, 85 community-dwelling men and women (age range 60-90 years) were randomised to either a supervised, progressive resistance toe training intervention or a home-based exercise group for 12 weeks, before being retested. A further 32 participants were recruited for a control group. Participants in the Toe Training group attended three 45-minute group exercise classes each week, for 12 weeks. The exercises, which were predominantly designed to strengthen the toe flexor muscles, progressively increased in level of difficulty throughout the intervention. The primary outcome measures were hallux and lesser toe flexor strength. Secondary outcome measures were components of the Foot Health Status Questionnaire.

**Results:** Average class attendance was 89% (range 62-100%) with 68 participants from the intervention groups (80%) completing the follow-up assessments. Participants in the supervised, progressive resistance toe training group significantly increased their hallux and lesser toe strength (up to 36%;  $P < 0.02$ ), whereas there was no significant change in toe strength in either the home-based or control groups. This increased hallux and lesser toe strength was accompanied by a significant improvement in perceived general foot health compared to the other groups ( $P < 0.05$ ).

**Discussion:** Our progressive resistance training intervention significantly increased strength of the toe flexor muscles in older adults. The exercise intervention now needs to be trialed in the community to determine whether these improvements in toe flexor strength can be translated into a reduction in the number of falls suffered by older adults.

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**Introduction:** ACL rupture may result in increased tibiofemoral laxity and impaired neuromuscular function, which ultimately may lead to knee instability and dysfunction. Individuals who opt to choose surgery, due to these changes, may be defined as “non-copers”. Conversely, “copers” may be defined as individuals with an ACL deficient knee who do not have functional impairment and instability and who successfully resume pre-injury activity levels without surgical intervention. The aim of this study is to first, explore the differences and outcomes between individuals who have had anterior cruciate ligament (ACL) reconstruction and those who did not undergo surgical intervention following a tear of the ACL. Second, to review the evidence related to the ability to identify individuals who may or may not need surgery after an ACL rupture. Finally, to describe the differences between copers and non-copers.

**Methods:** An electronic search was conducted up to April 2015, using medical subject headings and free-text words. Subject-specific search was based on the terms “anterior cruciate ligament reconstruction versus conservative treatment”, “copers”, “non-copers”.

**Results:** A similar percentage of copers and non-copers return to sporting activity. Three papers used an algorithm and screening examination involving individuals with ACL injuries. Evidence exists that, as opposed to copers, non-copers have: deficits in quadriceps strength, vastus lateralis atrophy, quadriceps activation deficits, altered knee movement patterns, reduced knee flexion moment, and greater quadriceps/hamstring co-contraction.

**Discussion:** ACL screening examination shows preliminary evidence for detecting potential copers. Objective differences exist between copers and non-copers. Individuals with ACL injury should be informed of the possibility of good knee function following a non-operative rehabilitation program.

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**Introduction:** Anterior cruciate ligament (ACL) rupture commonly affects young, physically active individuals. Evidence suggests that, as a result of such injuries, up to 50% of individuals may develop premature knee osteoarthritis (OA), often when aged in their 30s or 40s. Hence, individuals with an ACL injury, irrespective of how it is managed, represent a high-risk group for development of knee OA. Health risk knowledge is important to allow patients to make informed decisions regarding their health and develop behaviors or undergo treatment to change their risk. Furthermore, knowing patient preferences for potential treatments will provide insight into the feasibility of such treatments. The purpose of this survey was to explore patients' knowledge of OA and OA risk following ACL injury and/or reconstruction, extent to which information about these risks and potential treatments is provided to patients by health professionals, and patients' treatment preferences.

**Methods:** A custom-designed survey was conducted in Australian adults who sustained an ACL injury and/or had undergone ACL reconstruction one to five years prior. The survey comprised four sections: 1) demographics, 2) knowledge about OA and OA risk, 3) advice received from health professionals about OA risks, and 4) treatment preferences for reducing OA risk. Descriptive statistics were calculated and correlations examined amongst demographics, risk beliefs and treatment importance.

**Results:** Complete datasets from 210 eligible respondents were analysed. Most (n=148, 70.4%) rated themselves as being at greater risk of OA than healthy peers. Most agreed that ACL (n=147, 70.0%) and/or meniscal injuries (n=199, 75.8%) would increase this risk. Fifty-eight (27.6%) respondents recalled discussion of their OA risk with a health professional. Muscle strengthening and weight loss were most often recommended by health professionals and preferred by respondents compared to bracing, orthotics, or modified shoes. While female sex, lower body mass index and higher current physical activity levels positively correlated with beliefs about ACL injury, meniscal tears or meniscectomy as OA risk factors, history of professional advice positively correlated with these statements and treatment importance ratings.

**Discussion:** Individuals with a prior ACL injury seem aware of the higher risk of OA. Professional advice appears limited yet vital in improving patients' understanding of risks and importance of prevention. While most proposed prevention strategies were deemed acceptable, dedicated randomised controlled trials are warranted to determine efficacy of such strategies in reducing OA risks in these patients. Future research should further elucidate how to best educate both clinicians and patients.

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**Background:** Biomechanical deficits may drive early degenerative changes in anterior cruciate ligament reconstructed (ACLR) knees. To date, no comprehensive review of knee biomechanics in ACLR has been conducted. The aim of this study was to conduct a systematic review and meta-analysis of knee kinematics and moments in ACLR knees during walking.

**Methods:** Seven electronic databases and reference lists of relevant papers were searched for cross-sectional, human observational studies comparing knee kinematics and moments during walking in ACLR, with the uninjured contralateral or healthy control knees. Two independent

reviewers appraised methodological quality (modified Downs and Black scale). Where possible, data were pooled by time post-surgery, otherwise narrative synthesis was undertaken.

**Results:** 34 studies were included. Meta-analysis revealed significant sagittal-plane deficits in ACLR knees, with significantly greater knee flexion angles (standardized mean difference: 1.06, 95% confidence interval: 0.39 to 1.74) and moments (1.61, 0.87 to 2.35) in those <6 months post-surgery compared to healthy controls. However, lower knee flexion angles were identified at 1-3 years (-2.21, -3.16 to -1.26) and  $\geq 3$  years post-surgery (-1.38, -2.14 to -0.62). Those 6 to <12 months post-surgery had lower flexion moments (-0.76, -1.40 to -0.12). Data pooling revealed moderate evidence of no difference in peak adduction angles in those 6-12 months (-0.52, -1.11 to 0.08) and  $\geq 3$  years (0.34, -0.34 to 1.01) post-surgery. Limited evidence from single studies revealed no difference in peak knee abduction angles in those 6-12 months post-surgery (-0.48, -1.20 to 0.25); however, those 1-3 years and  $\geq 3$  years post-surgery had lower peak abduction angles (-0.77, -1.52 to -0.03; -1.91, -2.74 to -1.08, respectively). An interesting finding was the lack of evidence from pooled data for alterations in knee adduction moment (KAM). At 6-12 months (moderate evidence), 1-3 years (limited evidence), and  $\geq 3$  years (high evidence) post-surgery, there were no significant differences in KAM compared to controls (-0.61, -2.71 to 1.49; -0.39, -0.81 to 0.03; 0.09, -0.63 to 0.81, respectively). No transverse plane conclusions could be drawn.

**Discussion:** While KAM is an important risk factor for non-traumatic knee OA, it appears that sagittal-plane biomechanics are more relevant in ACLR knees, with differences in knee flexion angle and moment observed at various post-operative time points. Better understanding of sagittal-plane biomechanics may assist in enhancing post-operative recovery programs, and potentially prevent early-onset and progression of knee OA after ACLR.

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## Injury prevention and athletic performance are not mutually exclusive: An anterior cruciate ligament injury prevention training program

AWARD FINALIST

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**Background:** Significant research has been dedicated to injury prevention training programs with limited success in reducing ACL injury rates. A contributing factor to unsuccessful injury prevention programs are low athlete attendance, compliance and/or engagement. Though lower limb injury rates are high among elite level athletes, injury prevention programs are generally considered to be low priority as coaches have a misguided perception that there is an inverse relationship between prophylactic training and athletic performance. Recent literature has identified the dynamic strength and control of the hip and trunk during dynamic sporting tasks is of paramount importance for reducing an athlete's peak knee loading and injury risk in sport. The purpose of this study was to show that a biomechanically-informed ACL injury prevention training protocol is effective in reducing ACL injury rates, while simultaneously having no negative effect on athletic performance.

**Methods:** The Australian national women's hockey team participated in 25-weeks of biomechanically-informed injury prevention training (Weeks 1-9 *Intensive Training*: 4x20 minute sessions, Weeks 9-25 *Maintenance Training*: 3x10 minute sessions) implemented adjunct to their 2012-2013 regular season training schedule. Irrespective of the training genre (plyometric, balance and resistance), the overriding goal ([www.youtube.com/bodyfitworkouts](http://www.youtube.com/bodyfitworkouts)) was to improve the control of the trunk and hip during dynamic sporting tasks. Lower limb injury data during from the 2011-2012 (pre-intervention) and 2012-2013 (training intervention period) were collected. Prior to and following the *intensive* training phase (weeks 1-9), each participant's athletic performance (i.e., speed/agility, aerobic power, strength) were recorded as well as coach rated attendance, compliance and athlete engagement.

**Results:** Pre-intervention there were 0.53 knee injuries per player, and 0.07 non-contact ACL injuries per player. During the training intervention season, there were 0.77 knee injuries per player, and 0.00 non-contact ACL injuries per player. There were no changes in one-repetition maximum (1RM) bench press, bench pull and back squat scores following the training intervention. There was significant improvements in 10m sprint times ( $\downarrow 1.7\%$ ,  $p=0.023$ ) and aerobic power beep test scores ( $\uparrow 2.2\%$ ,  $p=0.022$ ). Attendance and compliance were  $81.1 \pm 25.0\%$  and  $88.2 \pm 19.7\%$  respectively, with attendance only missed due to injury. Athlete engagement was high with  $89.2 \pm 11.5\%$  commitment,  $89.9 \pm 11.2\%$  motivation and  $91.9 \pm 9.9\%$  perseverance.

**Discussion:** Biomechanically-informed injury prevention training is successful in reducing non-contact ACL injury rates, while also improving and/or maintaining athletic performance. These results provide valuable information to coaches and medical staff interested in implementing effective injury prevention training protocols in time-poor competitive season schedules without sacrificing athletic performance.

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## Is neuromuscular control during valgus knee loading associated with changes in tibial cartilage morphology following ACL reconstruction?

AWARD FINALIST

L. Jenkins<sup>1\*</sup> • K. Fortin<sup>1</sup> • X. Wang<sup>1</sup> • A. Bryant<sup>1</sup>

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**Background:** Patients who have undergone anterior cruciate ligament reconstruction (ACLR) exhibit altered lower limb biomechanics, particularly during high demand sporting activities. Over time, altered loading patterns are thought to contribute to a loss of knee joint cartilage in the ACLR involved knee – a predisposing factor in the development of debilitating knee joint osteoarthritis (OA). The aim of this study was to identify relationships between tibial acceleration transients during multidirectional hop landing tasks, and medial and lateral tibial cartilage morphology.

**Methods:** 55 individuals (36 males, 19 females) having undergone ACLR 2-3 years prior, using the combined semitendinosus/gracilis tendon graft, volunteered to participate in the study. All subjects performed a series of single-limb (involved) ipsilateral hop tasks – forward hop, and 45° hop from initial standing position to left and right to create valgus knee stress – at 75% of lower limb length with a 20g triaxial accelerometer fixed to the

proximal tibia. ACLR knees were scanned using MRI in order to quantify medial and lateral tibial cartilage volume. Pearson's product moment correlations were used to establish the strength of associations between biomechanical and knee cartilage measures.

**Results:** A significant ( $p < 0.05$ ) negative correlation was identified between time to stabilise in the medio-lateral plane; i.e. time for medio-lateral acceleration transients to remain stable for  $>1$  second at 0.25g, and normalised medial tibia cartilage volume ( $r = -0.291$ )

**Discussion:** The degree of neuromuscular control when landing in knee valgus is a determinant of medial cartilage volume at 2-3 years following ACLR. Specifically, ACLR subjects with lower cartilage volume took more time to stabilise the knee on landing from dynamic hop. Poor neuromuscular control in high demand tasks may influence cartilage health and the development of knee OA in the years following ACLR. Hence, prescription of dynamic neuromuscular training and the use of hop tasks in rehabilitation exercises post ACLR may enhance knee joint health in the longer term.

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## Return to sport explains variability in quality of life 5 to 20 years following anterior cruciate ligament reconstruction

AWARD FINALIST

S. Filbay<sup>1\*</sup> • I. Ackerman<sup>2</sup> • T. Russell<sup>1</sup> • K. Crossley<sup>1 3</sup>

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**Introduction:** Many individuals experience persistent knee symptoms, impairments in quality of life (QOL) and do not return to competitive sport 5-20 years following anterior cruciate ligament reconstruction (ACLR). However, specific factors associated with QOL in these individuals are poorly understood. This study will be the first to (i) describe QOL in people with knee symptoms  $\geq 5$  years following ACLR, and (ii) identify factors associated with QOL in these individuals.

**Methods:** We analysed baseline data from a longitudinal study of people who had undergone ACLR 5-20 years previously. All participants experienced knee pain, stiffness or activity limitations and were recruited from records of four experienced surgeons and community advertisements. Participants completed the ACL-QOL questionnaire, Knee injury and Osteoarthritis Outcome Score (KOOS), the AQL-8D and a demographics questionnaire. Multivariable linear regression was performed to identify factors explaining variability in QOL outcomes. Direct acyclic diagrams were used to select variables and covariates for use in regression analyses. Models were adjusted for potential confounders.

**Results:** 162 participants with a mean age of  $38 \pm 9$  years completed the questionnaires on average  $9 \pm 4$  years following ACLR. Over half of participants were overweight (34%) or obese (22%), 32% did not return to sport after ACLR, 28% returned to a lower level and 39% returned to the same or higher level of sport. Of those who ceased sport, 79% reported that this was due to their knee. Average KOOS-QOL ( $55 \pm 20$ ) and ACL-QOL scores ( $57 \pm 21$ ) were considerably lower than population norms and data from previous ACLR studies. AQL-8D values ( $0.80 \pm 0.14$ ) were slightly impaired compared to Australian population norms, exceeding the minimal important difference for people aged 49-55 years. Multivariate analyses revealed that returning to sport at the same or higher level compared with not returning to sport at all, explained the greatest amount of variability in QOL outcomes. Not returning to sport after ACLR was associated with poorer KOOS-QOL ( $\beta = .27, p = 0.003$ ), ACL-QOL ( $\beta = .47, p < 0.001$ ) and AQL-8D ( $\beta = .23, p = 0.01$ ) scores. Variance in QOL scores was partially explained by subsequent surgery, BMI and bilateral ACLR. All variables were still associated with QOL scores after adjusting for potential confounders (KOOS-pain, age and sex).

**Discussion:** QOL is impaired in people with knee difficulties 5-20 years after ACLR. Individuals who do not return to sport after ACLR may be at heightened risk of poor long-term QOL, and could benefit from management strategies aimed at optimising QOL and facilitating a physically active lifestyle.

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## Symposium: Oral contraception and the menstrual cycle in exercise science and sports medicine research – should it be considered?

M. Schaumberg<sup>1\*</sup> • X. Janse De Jonge<sup>2</sup> • H. Hillebrandt<sup>2</sup> • R. Fisher<sup>3</sup> • C. Minahan<sup>4</sup> • A. Han<sup>5</sup>

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**Introduction:** There has been an increase in the participation of women in recreational and competitive sport over the last two decades. However, applied sport and exercise science research in female populations has not followed the same trend. It is now clear that ovarian hormones may, in part, explain the gender-related differences apparent in athletic performance. Furthermore, hormonal contraception (e.g., oral contraceptives) adds complexity to this relationship through the introduction of circulating exogenous estrogen and progesterone, which may also alter the physiological responses to exercise and thus performance.

The aim of this symposium is to highlight current research examining the effects of the menstrual cycle and oral contraceptive use, on the response to exercise and consider the challenges of female-specific research. This symposium will firstly investigate the natural menstrual cycle and propose methods for use in research where stringent verification of hormone concentrations is required. Secondly, the symposium will investigate oral contraceptive use and its influence on exercise and training adaptations, thereby stimulating discussion on current knowledge and research gaps in the investigation of endogenous and exogenous ovarian hormones in exercise science and sports medicine.

Paper 1 will review hormone verification methods used in research investigating exercise performance over the menstrual cycle and Paper 2 will follow on from this by proposing and evaluating the effectiveness of a three-step method for ovarian hormone verification in research studies.

Paper 3 will investigate potential changes in body composition over the natural menstrual cycle. Paper 4 will focus on oral contraceptive use and its relationship with physical activity in Australian women. Paper 5 will investigate the influence of oral contraceptive use on the muscle metaboreflex and Paper 6 will investigate the influence of oral contraceptive androgenicity in exercise training adaptation. Following presentation of the six papers, the direction of research in menstrual cycle and oral contraceptive use and its application in exercise science and sports medicine will be discussed.

Paper 1: A review of menstrual cycle verification methods used in research investigating exercise performance over the menstrual cycle  
Paper 2: A three-step method for ovarian hormone phase verification in research studies  
Paper 3: Pilot study on body composition in females: effects of the menstrual cycle  
Paper 4: The role of physical activity in oral contraceptive use in Australian women  
Paper 5: Oral contraceptives alter the muscle metaboreflex to isometric handgrip exercise  
Paper 6: Effects of androgenicity in oral contraception on endurance training adaptation

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**Symposium: Oral contraception and the menstrual cycle in exercise science and sports medicine research – should it be considered? Paper Title: A review of menstrual cycle verification methods used in research investigating exercise performance over the menstrual cycle**

X. Janse de Jonge<sup>1\*</sup> • A. Han<sup>2</sup> • B. Thompson<sup>1</sup>

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**Introduction:** Eumenorrhic females are exposed to fluctuations in various hormones, such as estradiol ( $E_2$ ), progesterone (P), luteinising hormone (LH) etc. throughout the menstrual cycle (MC). Based on female steroid hormone fluctuations the MC can be divided into early follicular phase (low  $E_2$  and P), late follicular (or ovulatory) phase (high  $E_2$  and low P) and luteal phase (LP) (after ovulation, high  $E_2$  and P). In active females there is a large percentage of anovulation and luteal phase deficiency (LPD). To be able to draw conclusions about potential differences in exercise performance between MC phases, it is paramount to accurately verify if participants are experiencing a regular ovulatory MC. The aim of this study was to review recent research on exercise performance over the MC for methods of MC phase verification.

**Methods:** Databases (PubMed and SportDiscus) were searched for journal articles from 2006 till March 2015 with “menstrual” in the title and exercise or performance in any field. The search resulted in a total of 341 articles (232 PubMed and 109 SportDiscus). Duplicates were removed and articles were independently reviewed and selected by two authors (XJ & AH). Selection criteria included original research articles published in English comparing a measure of exercise performance between natural MC phases.

**Results:** The twelve selected articles all counted days from onset of bleeding to identify MC phases. To estimate the day of ovulation six studies included daily recording of basal body temperature (BBT). Two of these studies also measured urinary LH surge as a predictor of ovulation, while one used urinary LH surge without BBT. Six studies measured serum levels of  $E_2$  and P, while one only measured P. Of these seven studies, two mentioned that measured hormone levels were in normal range without further details. The other five studies set a minimum limit for P during LP, which ranged from 8 to 16 nmol·L<sup>-1</sup>. Only three of the twelve studies actually excluded participants for not meeting MC phase verification requirements.

**Discussion:** Out of the twelve studies selected, only five set a limit for LP verification and only three excluded participants who didn't meet this limit. Our findings highlight that many recent exercise science studies did not accurately verify MC phase and are very likely to have included anovulatory or LPD participants. To improve research quality clear standards for MC verification should be set, including at least a minimum P limit for LP verification.

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**Symposium: Oral contraception and the menstrual cycle in exercise science and sports medicine research – should it be considered? Paper Title: A three-step method for ovarian hormone phase verification**

M. Schaumberg<sup>1\*</sup> • D. Jenkins<sup>1</sup> • X. Janse De Jonge<sup>2</sup> • L. Emmerton<sup>3</sup> • T. Skinner<sup>1</sup>

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**Introduction:** Both endogenous and exogenous ovarian hormones have been shown to significantly influence a number of physiological parameters that in turn influence exercise capacity in females. Exercise research focusing on females remains limited and this may, in part at least, be due to limitations and complexity in assessing and controlling for hormonal fluctuations of the menstrual cycle. The present study investigated the effectiveness of a three-step method for the verification of menstrual cycle and oral contraceptive cycle phase.

**Methods:** Recreationally-active ( $PA > 150 \text{ min} \cdot \text{week}^{-1}$ ) women who were either long-term OC-users (OC;  $n=28$ ; age= $25 \pm 5$  years; mean  $\pm$  SD) or experiencing regular natural menstrual cycles between 25-40 days (MC;  $n=26$ ; age= $26 \pm 5$  years; mean  $\pm$  SD) completed three retrospective months of calendar-based menstrual cycle mapping to determine approximate cycle length and point of ovulation followed by a dual-energy x-ray absorptiometry scan for assessment of body composition. To confirm the point of ovulation, home urinary ovulation prediction testing based on the cycle length was completed and seven to 12 days following a positive ovulation prediction test a 6 mL venous blood was taken for measurement of serum oestradiol, progesterone, testosterone and sex-hormone binding globulin (SHBG) concentrations. A minimum criterion of 6 nmol·L<sup>-1</sup> serum progesterone was set for confirmation of mid-luteal menstrual phase.

**Results:** Following serum hormone analysis, 100% of OC-users were successfully classified into the high-hormone phase and 70% of MC participants were successfully classified into the mid-luteal phase (MC-NORM). OC had significantly higher SHBG ( $p < 0.01$ ) compared with MC; and MC had significantly higher oestrogen and progesterone concentrations (both  $p < 0.01$ ). The 30% of MC participants who did not meet the hormone criterion for mid-luteal phase despite successful identification of ovulation were classed as luteal phase deficient (MC-LPD). MC-LPD participants were younger ( $p < 0.01$  vs MC-NORM) and exhibited longer menstrual cycles, and lower body fat percentage, body mass and BMI (all  $p < 0.05$  vs MC-NORM). Binary logistic regression analysis including age, cycle length and body mass index correctly classified 92% of cases ( $p < 0.01$ ).

**Discussion:** The proposed three-step method for verification of hormone phase was 100% effective in OC-users, and 70% effective in MC-participants. Therefore, if stringent ovarian hormone control is necessary in a research study, women taking an oral contraceptive may be more suitable participants than naturally menstruating women. Where the inclusion of MC participants is necessary, the consideration of age, body composition and cycle length prior to study inclusion could inform a more accurate and cost-effective algorithm for successfully classifying hormone status in physically-active women.

## Symposium: Oral contraception and the menstrual cycle in exercise science and sports medicine research – should it be considered? Paper Title: Pilot study on body composition in females: Effects of the menstrual cycle

H. Hillebrandt<sup>1\*</sup> • B. Thompson<sup>1</sup> • A. Han<sup>2</sup> • X. Janse de Jonge<sup>1</sup>

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**Background:** As a result of the menstrual cycle women are continuously exposed to changing female steroid hormones during their reproductive years. Both oestrogen and progesterone cause many physiological effects, which includes changes in fluid regulation. It is known that renin-angiotensin-aldosterone components, which regulate fluid balance, are increased following an increase in endogenous oestrogen. Further, oestrogen has been shown to lower the osmoregulatory set point and alter body water distribution within extracellular space. In addition, adipose tissue comprised of both fat and fluid may change thickness as a result of such fluid alterations. Changes in body fluid regulation as a result of the fluctuating menstrual cycle hormones may therefore affect body composition measures over the menstrual cycle. The aim of this study was to investigate if there is a difference in body composition between the phases of the menstrual cycle.

**Methods:** Women aged 24-42 years (n=7) with a regular menstrual cycle (not on oral contraceptives for at least 6 months prior) volunteered to participate in three testing sessions throughout a menstrual cycle. Testing correlated with cycle phase and occurred during day 1-4 (early follicular phase); day 10-13 (late follicular phase); and day 19-23 (mid-luteal phase). Whole body dual x-ray absorptiometry (DXA) scans, bioelectrical impedance analysis (BIA) and urine specific gravity (USG) were measured. Ovulation was confirmed through measurement of urinary LH surge using OVUNOW ovulation test strips (Fertility Solutions, Australia).

**Results:** Repeated measures ANOVA showed no significant differences over the menstrual cycle for variables USG, BIA % fat, BIA % water, and DXA % fat. The mean over the menstrual cycle for USG was 1.009 with a 95% CI of 1.001-1.018. Mean cycle BIA % fat was 27.6% with 95% CI of 20.5%-34.7%, and mean cycle BIA % water was 52.4% with 95% CI of 46.4%-58.6%. The DXA % fat cycle mean was 29.8% with 95% CI of 22.8%-37.0%.

**Discussion:** This pilot study showed no differences in body composition measured by BIA and DXA over the menstrual cycle. Furthermore USG did not change, so it is unlikely that differences in hydration status are related to potential changes in body composition over the menstrual cycle. A healthy hydration level utilising USG is between 1.000-1.030, therefore all of our subjects were found to be well hydrated. The data suggests that a shift in osmoregulatory set point associated with increased oestrogen may not affect body composition measures.

## Symposium: Oral contraception and the menstrual cycle in exercise science and sports medicine research – should it be considered? Paper Title: The Role of Physical Activity in Oral Contraceptive use in Australian Women

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**Background:** Between 2001 and 2011 it was reported that between 25-76% of Australian women were taking oral contraceptives (OC). The reason(s) for this large range in prevalence rate among different population samples is largely unknown. Several survey-based studies have investigated the “benefits and barriers” for OC use within the general population, however it is unknown how physical-activity level affects the prevalence rate of OC use. The aim of the present study was to investigate the prevalence rate and benefits and barriers for OC use within Australian women of varying physical activity levels.

**Methods:** Australian women were recruited via social media and included women who were considered sedentary (i.e., SED; no physical activity; n = 8, 30.0 ± 5.2 yr), untrained (i.e., LOW; 150 – 300 min/wk of moderate-intensity exercise or equivalent; n = 34, 31.3 ± 9.1 yr), moderately active (i.e., MOD; 450 – 600 min/wk of moderate-intensity exercise; n = 45, 30.8 ± 7.8 yr), highly active (i.e., HIGH; 750+ min/wk of moderate-intensity exercise; n = 25, 27.6 ± 5.2 yr), or athletic (i.e., ATH; currently competing at state or national level; n = 36, 30.2 ± 12.2 yr). All women completed an online survey of twenty-five questions examining their OC use.

**Results:** The prevalence rate of OC use was higher in the MOD (46%) and HIGH (44%) women as well as ATH women (44%) when compared to SED (12%) and LOW (38%) women. After birth control, cycle control was the most highly selected reason for OC use in all women. Side effects were a common reason for not taking OC in all women across physical-activity level; weight gain was a major concern for SED (75%), LOW (75%) and MOD (77%) women as well as in HIGH (44%) and ATH (36%) women. However, the presence of synthetic hormones was also selected as a common reason for not taking OC in HIGH (64%) and ATH (48%) women.

**Discussion:** OC use is more prevalent in active women when compared to women who are considered sedentary or inactive. This suggests that physical-activity level may, in part, play a role in the use of OC in Australian women. The lower prevalence rate in SED and LOW women may be due to the barrier of weight gain, whereas more highly-active women are less concerned with weight gain; reflecting a greater daily energy expenditure.

**Symposium title: Oral contraception and the menstrual cycle in exercise science and sports medicine research – should it be considered? Paper Title: Oral contraceptives alter the muscle metaboreflex to isometric handgrip exercise**

C. Minahan<sup>1\*</sup>

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**Background:** Endogenous sex-steroid hormones play an important role in the gender-related effect on the response to exercise. As such, it is plausible that the suppression of endogenous hormones, by means of oral contraceptive (OC) administration, alters the exercise response among women. Measurement of the changes that occur in BP during and after (with/without post-exercise arterial occlusion) isometric handgrip exercise, provides a useful experimental model with which to examine the effect of OC on skeletal muscle mechano- and metabo-reflexes (known collectively as the exercise pressor reflex; EPR). Given the evidence demonstrating that fluctuations in endogenous estrogen across the ovarian cycle alter the EPR, we hypothesized that the EPR response would be altered in women taking OC (WomenOC) compared with normally-menstruating women (WomenNM).

**Methods:** Maximal voluntary isometric contraction (MVC) for handgrip was measured in young (18-35 yr) recreationally-active WomenNM (n = 10) and WomenOC (n = 10). BP was continuously measured using a Finapres during two handgrip trials comprising 10 min of baseline, 3 min of isometric handgrip exercise at 30%MVC, 3 min of passive recovery, and 5 min of rest. The two trials differed only during the recovery period whereby arterial occlusion was applied to the upper arm immediately before the end of handgrip exercise and throughout recovery in one trial (OCL trial), and no occlusion was applied in the other (CON trial).

**Results:** Baseline systolic (S) BP measured and averaged across the two handgrip trials was not different between WomenNM (~105 mmHg) and WomenOC (~106 mmHg). The increase in SBP during handgrip was greater in WomenOC (~26 mmHg) compared with WomenNM (~15 mmHg). After recovery in the CON trial, SBP in both groups returned to a value not different from baseline. During the OCL trial, SBP returned to a value not different from baseline in WomenNM, but SBP remained elevated in WomenOC.

**Discussion:** The greater increase in SBP during handgrip in WomenOC compared to WomenNM can be attributed in part, to a greater muscle metaboreflex-induced pressor response in WomenOC. This is indicated by the maintenance of handgrip SBP observed during post-exercise arterial occlusion in WomenOC while returning to baseline in WomenNM. The findings of the present study suggest that chronic exposure to exogenous estrogen or the removal of endogenous estrogen, with OC administration, may alter cardiovascular function during exercise.

**Symposium: Oral contraception and the menstrual cycle in exercise science and sports medicine research – should it be considered? Paper Title: Effects of androgenicity in oral contraceptives on adaptations to endurance training**

A. Han<sup>1\*</sup>, E. Sung<sup>1</sup>, P. Platen<sup>1</sup>

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**Introduction:** Approximately 70% of reproductive aged females use oral contraceptives (OC). Monophasic OC preparations are the most prevalent, which contain fixed doses of ethinyl-estradiol and progestin for 21 days followed by 7 days withdrawal. Some progestins in OC have androgenic effects, which means these progestins can produce masculine characteristics and may affect training adaptations. The aim of the present study was to investigate if androgenicity in OC affects adaptations to endurance training.

**Methods:** Fourteen women using monophasic OC volunteered for this project. One group (n=7) used OC without any androgenic potential (A=0), and the other group (n=7) used OC with known androgenicity (A>0). To differentiate between the different hormonal environments throughout the OC cycle two training programs were designed to either focus on higher training load during the low hormone part of the OC (7 withdrawal days and first 7 days of OC) or the high hormone part of the OC (final 14 days of OC). Over 3 OC cycles participants performed cycle ergometer training with one leg mainly in the low hormone part (LHT) and the other leg mainly in the high hormone part (HHT). Peak oxygen uptake ( $VO_{2peak}$ ), maximal power output ( $P_{max}$ ) and power output at a lactate concentration of 4mmol/L ( $P_{lac4}$ ) were assessed prior to and upon completion of the training programs.

**Results:**  $VO_{2peak}$  in A>0 group tended to increase to a lesser extent in HHT compared to LHT ( $p=0.096$ ), while the A=0 group showed no difference in increase in  $VO_{2peak}$  between training programs.  $P_{max}$  showed similar increases for both training programs in the A>0 group and the A=0 group. Increase in  $P_{lac4}$  showed no difference between training programs in the A>0 group, while in the A=0 group  $P_{lac4}$  increased more after HHT than LHT ( $P = 0.082$ ).

**Discussion:** Effects of androgenicity in OC on adaptations to endurance training are inconsistent. While  $VO_{2peak}$  increased less under androgenic influence in HHT,  $P_{max}$  remained unaffected by androgenicity, and the submaximal performance parameter  $P_{lac4}$  increased more without the influence of androgenicity in HHT. The utilisation of different progestins in OC and their associated progestational and androgenic activity and the different lengths of time to exert their effect on training adaptations are likely to lead to inconsistent results in OC research. It is recommended that the androgenicity of OC is reported and taken into consideration in future OC research.

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## THURSDAY 22 OCTOBER POSTERS AT A GLANCE

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### Participation in modified sports programs: A longitudinal study of children's transition to club sport participation

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**Introduction:** Many children are not sufficiently physically active for a health benefit. While there are many different ways children can be physically active, sport is a type of physical activity that is popular amongst children. This longitudinal study identified trends in modified sport participation, including continuation in the modified sports program, withdrawal from the program or transition to community level sports club participation, among children aged 4-12 years.

**Methods:** De-identified data on participant membership registrations in three popular sports in the Australian state of Victoria were obtained from each sport's state governing body over a 4-year period (2009-2012 for one sport and 2010-2013 for two sports). From the membership registrations, those who were enrolled in a modified sports program in the first year were tracked over the subsequent three years and classified as one of: transitioned (member transitioned from a modified sport program to a club competition); continued (member continued participation in a modified sport program; or withdrew (member discontinued a modified program and did not transition to club competition).

**Results:** 209,336 children (64% male) participated in one of three modified sports programs in the base year. Many modified sports participants were very young, especially males aged 4-6 years. Fewer than 25% of females and fewer than 14% of males transitioned from a modified sports program to community level sports for competition/participation within a 4-year period. There were age differences between when boys and girls started, withdrew and transitioned from the modified sports programs. Very few children (4% females and 2% males) continued in a modified sports program for the whole 4-year period. Over two thirds of children withdrew immediately after the base year (67%).

**Discussion:** Very few children transitioned to community level sports club competitions/participation within a 4-year period. There were also differences in gender in terms of when boys and girls start and transition or withdraw from the modified sports programs. This study highlights considerations for the development and implementation of sport policies and programming, whereby the same program may not be suitable for both boys and girls, nor across the age spectrum of 4-12 years. Further, there is a need for better links between modified programs and community level sports club competition/participation to maintain sport participation as children age. If we can retain children in sport it will be beneficial for their health.

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## Four-year trends in sport participation and retention: the gender differences

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**Background:** There is evidence that physical activity declines during adolescence, especially for females, and that females generally have lower rates of participation in sport than males. There is, however, limited knowledge about participation trends by gender in organised, club-based sport, either cross-sectionally across the lifespan or longitudinally. The measurement and analysis of sport participation data is vital to provide the sport management and public health sectors with the evidence to make informed decisions about sport programming and policy. The aim of this study was to identify sport participation retention and dropout trends across the lifespan, by gender, in four popular Australian sports over a 4 year period, with a particular focus on the ages 4-14 years where most participation occurs.

**Methods:** All Victorian participant membership records from four popular team sports over a 4-year period were analysed: 2009-2012 for two sports and 2010-2013 for two sports. All participants in the base year were tracked over the 4-year period, and classified as either a 1-year participant, a discontinuous participant, or a continuous participant.

**Results:** A total of 408,544 participant records were analysed, comprising 69% males and 31% females. Across the lifespan, except for the 4-year olds, at least 40% of participants in each age band participated continuously. Rates of continuous participation were much lower for ages 4-6 years (32%-42%), and generally lower for females than males. The retention rates for those aged 4-5 were considerably lower for females (14%-24%) than that for males (34%-35%). There were high rates of continuous participation for those aged 10-14 before considerable declines with age. Participation trends across the lifespan were generally consistent for males (except at age 4) whereas for females the participation patterns fluctuated more.

**Conclusion:** The high numbers of very young participants (4-6 years) and corresponding low retention rates require further investigation, as does the much lower rates of retention for females in general. There is a growing body of evidence regarding the barriers to participation for females. This information needs to be applied and perhaps new sport offerings are needed, which take into account the factors contributing to low participation and retention rates from late adolescence (15 years) through to adulthood, specifically for females.

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## A Novel Approach to Predict Repeatability of Performance in Older Adults: Coefficients of Variation for Strength and Functional Measures

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**Introduction:** Reliable measures of muscle strength and function in older adults are essential for meaningful clinical assessments and to enable accurate conclusions to be made about interventions. However, multiple familiarisation sessions prior to assessments to ensure reliability are not feasible in many settings. Coefficients of variation (CVs) could be an efficient means of determining if an individual can produce repeatable subsequent performances in tests of muscle strength and function. The aims of this study were to determine: (i) whether CVs for each participant at the first test session can predict repeatability of performance in a subsequent session; and (ii) the level of CV that produces acceptable repeatability (<6% variation between the first and second test).

**Methods:** Forty-eight healthy older adults (average age 68.6±6.1 years) completed two assessment sessions (S1 and S2), and on each occasion undertook: Isokinetic dynamometry for isometric and isokinetic quadriceps strength (60, 120, 240 and 360 °/s), 6 metre fast walk (6mFWT), timed up and go (TUG), stair climb and descent, and vertical jump.

**Results:** Significant linear relationships were observed between CVs in S1 and the percentage difference between S1 and S2 (%diff) for torque at 60°/s ( $r=0.484$ ;  $P<0.01$ ), 120°/s ( $r=0.730$ ;  $P<0.01$ ), 240°/s ( $r=0.702$ ;  $P<0.01$ ) and 360°/s ( $r=0.329$ ;  $P<0.05$ ), 6mFWT ( $r=0.336$ ;  $P<0.05$ ), TUG ( $r=0.372$ ;  $P<0.01$ ), stair climb ( $r=0.529$ ;  $P<0.01$ ) and stair descent ( $r=0.340$ ;  $P=0.01$ ). Participants who in S1 achieved CVs of less than 2.84% in the 60°/s, 120°/s, 240°/s and 360°/s dynamometer tests were likely ( $P<0.05$ ) to have a %diff of less than 6%. Participants who achieved CVs of less than 4.50% in the 6mFWT and stair climb test in S1 were likely ( $P<0.05$ ) to have a %diff of less than 5%. Participants who achieved CVs of less than 1.37% in the TUG were likely ( $P<0.05$ ) to have a %diff of less than 6%. Males who achieved CVs of less than 0.18% in the stair descent test in S1 were likely ( $P<0.05$ ) to have a %diff of less than 6% while females who achieved CVs of less than 2.79% in the stair descent test in S1 were likely ( $P<0.05$ ) to have a %diff of less than 5%.

**Discussion:** Coefficients of variation can predict repeatability of performance in individuals in some tests, and may therefore be used to determine whether further familiarisation is required prior to the attainment of valid and reliable assessment data.

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## Development of a valid and reliable musculoskeletal screening protocol for Australian football

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**Introduction:** Musculoskeletal (MSK) screening is commonly conducted for Australian football (AF) players and the screening results are intended to identify modifiable factors to reduce future injury. For a MSK screening protocol to be useful, the tests used must have predictive validity and be reliable. A standardised MSK screening protocol suitable for a wide variety of ages and skill levels would allow consistent player information to follow players as they moved clubs, and also facilitate future research. The purpose of this project was to develop a valid and reliable standardised MSK screening protocol for AF.

**Methods:** A mixed methods approach was adopted for this project. Focus groups of physiotherapists with experience with AF and elite sport were convened. The physiotherapists were asked to volunteer which MSK screening tests they used and why. A list of the tests was compiled and a search of the literature was conducted to confirm the predictive validity and reliability of these tests. Based on this information, a MSK screening protocol was developed and evaluated during two trials; at the Under 16 National Championships and the AFL Draft camp. The results for the trials were used to modify the MSK screening protocol to produce the final version.

**Results:** A MSK screening protocol with three levels of tests was finalised. Level 1 tests were the tests with demonstrated predictive validity and high reliability. Level 2 tests had moderate reliability and had clinical utility. Level 3 tests had unknown or poor reliability, yet were potentially clinically relevant.

**Discussion:** The development of a valid and reliable standardised MSK screening protocol will enable a consistent approach to MSK screening of AF players. It also provides the basis for prospective longitudinal risk factors research projects for AF. This project was funded by the AFL Research Board.

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## A comparative and qualitative Electromyographic Analysis of Shoulder and Wrist Muscles in Cricket Fast Bowlers during Bouncer and Yorker Delivery.

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**Introduction:** Cricket is one of the most popular sports, played in many countries worldwide. The T20 is the shortest format of game that makes it more fascinating. However due to aggressive in nature it could be more prone for risk of injuries to shoulder and wrist in fast bowlers. Thus the purpose of the study was to determine the EMG activity and associated risk of shoulder and wrist injuries in fast bowlers while bowling 'Bouncer' and 'Yorker' deliveries.

**Methods:** A total of 17 healthy participants including 15 right-handed and 2 left handed fast-medium bowlers were recruited who volunteered into study under the convenience sampling method. The demographics of the bowlers are as follows: n = 15, age = 27.3 ± 5.2 years, height = 173.1 ± 6.8 cm and weight = 75.1 ± 7.8 kg. The cross-sectional, experimental design of the study took place in the Robert Gordon University Laboratory, Scotland. A colored high speed camera (EXILM CASIO-EX-FH 25) was used to capture the bowling motion synchronized with EMG device (model- m 320RX, 5VDC/1A/5W, myon AG Switzerland) for data collection and analysis. Seven tested muscles were biceps brachii, middle deltoid, supraspinatus, infraspinatus, latissimus dorsi, flexor carpi radialis, extensor carpi radialis brevis. SENIAM guidelines were followed to apply the AgCl EMG electrodes.

**Results:** A significant difference in RMS was found in shoulder and wrist muscles while bowling bouncer and Yorker in first and second phase with p value of 0.0 and 0.05 respectively. Friedman's test was used to yield the following result. In comparison to individual muscles Biceps brachii has the maximum electrical activity of all shoulder and wrist muscles whereas Supraspinatus showed significantly less activity in second and third phase for Yorker deliveries. The eccentric activity in external rotators of the shoulder was less compared to higher concentric activity in internal rotators while bowling bouncers in the ball release and deceleration phase whereas similar finding was seen at wrist in bowling Yorkers.

**Discussion:** Based on the inferential statistics, cricket bowlers are highly exposed to risk of shoulder and wrist injuries with introduction of T20I and high demand of these bowling styles. The findings of the study are novel and would hold strong significance in the area of cricket and similar sports activities. Kinematic and kinetic analysis should be used to strengthen the study with greater attention and techniques by coaching and training standards.

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## Reliability of a repeat sprint ability protocol on a non-motorised treadmill in young, healthy, active adults

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**Background:** Repeat sprint ability (RSA) has been well documented as a key factor for team sport performance with single set, repeat sprint (RS) protocols recommended for the assessment of RSA. Several RS protocols exist for cycling, field running and motorised/non-motorised treadmills with most incorporating 5-10 repetitions of 3-6 second efforts. But little information exists about the reliability of RS protocols. Therefore, the aim of the current study was to examine the reliability of performance during a RS protocol using a non-motorised treadmill.

**Methods:** Twenty (13 males, 7 females) healthy, active, adults (mean age 22.0 years, range 18-31 years) volunteered for this study and completed a RS protocol using a non-motorised treadmill on 3 different occasions with each separated by ~14 days. Participants completed a standardised warm-up followed by a RS protocol that consisted of 1 bout of 5 x 4-second sprints with 20-seconds of active recovery between sprints. During each sprint, peak and mean velocity, peak and mean power, total work and 1-second acceleration were assessed. Comparisons between occasions or

trials were examined via 1-way repeated-measures ANOVA or Friedman's tests with post-hoc comparisons. Reliability was assessed via intraclass correlations coefficients (ICC) and typical error expressed as a coefficient of variation (CV).

**Results:** Most variables assessed during Trial 2 (69.4%) were significantly ( $p < 0.05$ ) greater than Trial 1 values with 44.4% of Trial 3 values also significantly greater than Trial 1 values. Reliability (ICC) for Trials 2 and 3 was excellent ( $p < 0.001$ ) for peak (0.97-0.98) and mean (0.98-0.99) velocity, peak (0.89-0.93) and mean (0.98-0.99) power, total work (0.98-0.99), and acceleration (0.92-0.97). The CV were small for most variables including peak (2.3-2.6%) and mean velocity (2.2-2.8%), mean power (3.3-4.6%) and total work (3.3-4.6%). Slightly greater CV were identified for peak velocity (9.8-13.6%) and acceleration (5.5-10.0%).

**Discussion:** The present study has demonstrated this non-motorised, treadmill RS protocol to be highly reliable for the assessment of RSA in young, healthy, active adults. Optimal assessment of RSA via this RS protocol was achieved after 1 practice or familiarisation trial. The current non-motorised, treadmill RS protocol provides an efficient and reliable tool for the assessment of RSA.

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## Shoe-surface interaction and lower extremity injury in the football codes: a Systematic review and meta-analysis

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**Introduction:** Interaction between athlete's footwear and the playing surface is an important risk factor for non-contact lower extremity injury. Turning or cutting on a planted foot may be an important inciting event for lower limb injury, particularly when shoe-surface traction is high. The purpose of this systematic review was to examine the relationship between shoe-surface interaction and lower-extremity injury in football sports.

**Methods:** A systematic literature search of four databases was conducted up to August 2014. Prospective studies involving human subjects, of any age, participating in the football codes were included. Studies must have reported lower limb injury data and shoe surface rotational traction derived from standardized mechanical measurements. To keep the mechanical testing methods as close as possible to game relevant loading scenarios, included studies measured rotational traction using a portable testing device (artificial foot fitted with commercially available football shoes on the actual playing surface). Two researchers independently extracted outcome data and assessed the quality of included studies using a modified Downs and Black index. Effect sizes (odds ratio + 95% confidence intervals) were calculated using RevMan software. Where possible, data were pooled using the fixed effect model.

**Results:** 3 Prospective studies were included, involving a total of 4972 male athletes. Methodological quality was generally good with studies meeting 68-89% of the assessment criteria. All studies categorized athletes into low (lowest mean value 15Nm) or high traction groups (highest mean value 74Nm) based on standardized preseason testing. In all cases, injury reporting was undertaken prospectively over approximately 3 seasons, with verification from a medical practitioner. Injury data focused on either: all lower limb injuries, ankle/knee injuries, or ACL injury only. There was clear relationship between rotational traction and injury and the direction and magnitude of effect sizes were consistent across studies. Pooled data from the three studies (OR=2.73, 95% CI 2.13 to 3.15;  $\text{Chi}^2 = 3.19$ ,  $\text{df}=2$ ,  $p=0.21$ ;  $I^2=36.5\%$ ) suggests that the odds of injury are approximately 2.5 times higher when higher levels of rotational tractions are present at the shoe surface interface.

**Discussion:** This systematic review has shown that high rotational traction influences lower limb injury risk in American football. Pooled data suggests that the odds of injury are approximately 2.5 times higher when higher levels of rotational tractions are present at the shoe surface interface. Further systematic investigation in other football codes is suggested.

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## Regional practitioners receive no formal training or support when prescribing exercise to pregnant women

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**Introduction:** The benefits of exercise during pregnancy for both mother and child are well documented. Despite these well-established benefits, very few Australian pregnant women are sufficiently active in accordance with exercise during pregnancy guidelines. Health practitioners play an integral role in helping pregnant women become sufficiently active. In an attempt to assist practitioners' to confidently deliver evidence-based exercise prescription to pregnant women, exercise during pregnancy guidelines and screening tools have been developed by peak industry bodies around the world. Given that most pregnant women look to their practitioners for credible exercise advice, it is important to further examine why practitioners may not be currently promoting exercise among their pregnant patients. Thus, the purpose of the present study was to examine Australian practitioners' knowledge of exercise during pregnancy guidelines, what training they received and if they are confident in providing exercise advice to their pregnant patients.

**Methods:** A convenience sample ( $n=50$ ) of practitioners including general practitioners and obstetricians currently practicing in Rockhampton, Queensland were invited to participate in the study. Each participant was surveyed using a 28-item instrument. Surveys were made available between January-September, 2014. Descriptive analyses were used to access practitioner knowledge of exercise during pregnancy guidelines, what training (if any) they have received and if they are confident in offering prescriptive exercise advice to their pregnant patients.

**Results:** Of the 50 practitioner participants, very few (8%) reported being '*familiar with at least one exercise during pregnancy guideline*'. Practitioners who reported receiving '*some form of formal training on exercise during pregnancy*' were scarce (4%). No practitioner reported being familiar with '*any screening tools that can be used to help prescribe exercise among pregnant women*'. '*Confidence in providing exercise prescription advice to their pregnant patients*' was reported among less than half (42%) of the practitioner participants.

**Discussion:** Practitioner advice can be a powerful motivator to increase physical activity levels because of the perceived practitioners' credibility and authority, especially among pregnant women who consider pregnancy as the opportune time to implement healthy lifestyle changes. However, practitioners in this study received no formal training or support in exercise prescription for pregnancy women, were unaware of exercise during pregnancy guidelines and/or screening tools and lacked confidence in their counselling abilities. To increase exercise among Australian pregnant women, practitioners need to be appropriately trained, with ongoing supported and professional development warranted.

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**Introduction:** Lack of physical exercise, is one of the major issues of the current lifestyle. The most common consequence is the increase in overweight and obesity and decrease of physical fitness. The regular exercise regimen has currently in the Czech Republic about 17-18% of the whole female population. In the Czech Republic we have currently about 52% of women overweight and obese are then 35% of women 18-65 years. We have currently about 19% of girls are overweight and obese are then 11% of girls aged 6-14 years. The basic questions needed to be answered when designing exercise intervention for BM reduction: Are the exercise assumptions affected by overweight or obese state?

**Method:** The exercise predispositions can be evaluated by the extracellular (ECM) and intracellular (BCM) mass ratio. To verify the dependence of the ECM/BCM on BM we calculated ECM/BCM for girls (normal BM, N=546, age=12.8±3.7yrs, BMI=19.5±0.2kg.m<sup>-2</sup>; overweight, 148, 12.6±3.2, 24.7±0.4; obese, 95, 12.9±3.4, 29.6±0.6), adult (98, 42.3±4.6, 23.5±0.6; 84, 42.8±4.5, 28.4±0.8; 76, 42.9±4.7, 32.8±0.9) and seniors (18, 69.4±2.6, 26.6±0.8; 15, 69.8±2.5, 29.6±1.0; 26, 68.9±2.3, 34.8±1.2). The body composition variables were determinate by bioimpedance analysis with use of predicting equations that have been validated for the Czech women's population.

**Results:** The using of ECM/BCM for evaluation of physical exercise predispositions was confirmed by the significant dependence of VO<sub>2max</sub> on this variable (r=-0.721, p<0.001 in children, r=-0.756, p<0.001 in middle aged women, and r=-0.815, p<0.001 in seniors). In all groups we did not find significant differences in the ECM/BCM in of the same age subjects differing in BM (ECM/BCM was in girls – obese = 0.90±0.02, overweight 0.90±0.03, in normal body mass 0.88±0.03, and in middle age women – 0.88±0.03, 0.89±0.02, 0.87±0.04, and in seniors 1.02±0.03, 1.05±0.03, 1.08±0.02) and non-significant dependence of ECM/BCM on their BM. We find significant positive dependence of ECM/BCM on age (r=0.703, p<0.001).

**Discussion:** The data implies that the coefficient of ECM /BCM can be used as an important predictor for the expected load movement. In practice this means that the coefficient of ECM / BCM can be used not only to assess the applied movement regime, but also for evaluating the effectiveness of the applied movement program. The morphological predispositions for exercise are not dependent on BM, and thus do not exist any objective limitations for regular exercise realized in the women with higher BM.

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**Background:** Professional Taekwondo athletes are frequently doing unilateral exercises in unnatural positions and may cause many postural abnormalities in the teenagers. This study aimed to study the effects of individualized an special corrective exercise program on the postural abnormalities.

**Methods:** Thirty-six teenage male Taekwondo athletes (11-16 years), recruited by random sampling. After pretest, 8-week corrective (experimental) or routine (control) programs performed and then posttest evaluation test was implemented. Postural assessment was done by means of three digital cameras to take anterior, lateral, and posterior images. A computerized dynamometer was used to do simultaneous right & left side shoulder lift, simultaneous right & left side arm lift, dual hands press, and dual hands pull. Control group continued their routine exercise program and experimental group performed eight-week corrective exercise program including stretching, flexibility, and strength exercise during three sessions 2 h/week one day after regular training.

**Results:** In the experimental group, the rate of abnormalities significantly decreased in the winged scapula (50%), kyphosis (45%), lordosis (35%), unilateral dropped shoulder (25%), and forward flexion (25%) but the control group had new incidences of forward head (two cases), kyphosis (two cases), lordosis (one case), unilateral dropped shoulder (five cases), and winged scapula (two cases). No significant difference seen between isometric force tests in both groups.

**Discussion:** The rational for the occurrence of these abnormalities among the Taekwondo athletes could be related to prolonged exercise with high intensity and mostly unilateral exercises and neglect in stretching and strengthening the opposite side muscles. Hence, doing corrective exercise is very effective in reduction of postural side effects of Taekwondo training in teenagers.

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**Background:** Decline in physical fitness and activity levels of adolescents in recent decades has become a global concern. Meanwhile, Hui et al. (2015) reported that Japanese adolescents had the highest moderate-to-vigorous physical activity level (MVPA) and endurance performances among Asian countries. In Japan, students are strongly encouraged to engage in a club activity at school. Accordingly, Suzuki et al. (2015) suggested that promotion of sports club activity at school helped to modify students' behaviours, and countered the decline in physical fitness and activity levels. However, it was not clear whether the club activity, expected to increase physical activity levels at school, would decrease sedentary behaviours. The aim of this study was to examine the influence of sports club activity on MVPA and sedentary behaviour of Japanese adolescents.

**Methods:** Students in Tokyo aged 12-15 years (847 males and 761 females) were recruited by stratified sampling according to the regional characteristics. Survey items included time spent on physical activity per week (self-reported MVPA; IPAQ), time spent sitting per day (WHO Health Behavior in School Children survey), and whether or not students engaged in sports club activity at school.

**Results:** 56.7% of males and 39.2% of females engaged in sports club activity at school. Sports club group showed significantly higher MVPA levels than non-club activity group for both males (984 vs. 381 min/wk) and females (682 vs. 189 min/wk) (p < 0.001). Time spent sitting was significantly less for the sports club group than non-sports club group for males (418 vs. 481 min/day, p = 0.001). However, time spent sitting was

similar between the two groups for females (524 vs. 528 min/day). The effect sizes of sports club activity on time spent sitting (males: 0.240, females: 0.020) were much smaller than the effect sizes on MVPA (males: 0.770, females: 1.220).

**Discussion:** Engaging in sports club activity at school obviously increases MVPA levels for both males and females. For females, sedentary behavior is, however, not reduced by sports club activity. Time spent for sports club activity was much longer for males than females (984 vs. 682 min/wk). Thus, the significant reduction of sedentary behaviour with sports club activity in males may be simply explained by lack of chances to seat themselves.

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## The role of mental health in the relationship between walking and cognitive ability in older adults in Indonesia

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**Introduction:** Dementia is a global issue with nearly 35.6 million people currently living with dementia worldwide. As there is currently no cure for dementia, modifiable lifestyle behaviour, such as physical activity, have been investigated as a preventative strategy to delay onset and prolong independent living. There are inconsistent results across exercise interventions designed to improve cognitive performance despite the large number of high quality trials. Previous evidence suggests positive effects of physical activity on mental health and the association between mental health and cognitive performance. Thus, this study aimed to investigate the role of mental health in the relationship between physical activity and cognitive performance.

**Methods:** Cross-sectional data were collected from 719 community dwelling participants (mean age 69.4, range 52-98, 65% female) living in rural and urban areas in Indonesia using opportunity and convenience sampling. Walking frequency and mental health status were captured using self-report measures. Cognitive ability was assessed using validated and culturally adapted versions of The Mini Mental Status Examination and Hopkins Verbal Learning Test.

**Results:** Hierarchical regression models for the whole group indicated a partially mediating role of mental health in the relationship between walking and cognitive ability. Mental health and functional health were independent predictors of cognitive ability. Walking remained a significant independent predictor of all cognitive outcome measures when controlling for mental health and covariates. Functional health attenuated the effect of walking frequency but not mental health on cognitive ability. Hierarchical regression models for participants with poorer mental health (median split) indicated that walking was a significant independent predictor of global cognitive ability and verbal learning while controlling for covariates. Mental health was a significant independent predictor of all cognitive outcome measures and did not attenuate the effect of walking. Hierarchical regression models for participants with better mental health indicated that walking was not a significant independent predictor of any cognitive outcome measures, even before controlling for mental and functional health.

**Discussion:** The results indicate a potential role of baseline or change mental health status to moderate or mediate the efficacy of exercise interventions aiming to improve cognitive ability in older adults. The common positive effects of physical activity and mental health on cognitive outcomes could indicate that physical activity which leads to improvements in physical fitness as well as improved mental health may bring about the largest beneficial effect on cognitive outcomes.

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## Quality of life in anterior cruciate ligament deficient individuals: A systematic review

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**Introduction:** Physical and psychological impairments impacting quality of life (QOL) are common following anterior cruciate ligament reconstruction (ACLR). Rehabilitation alone is an effective alternative to ACLR for some patients, warranting the investigation of QOL in ACL deficient (ACLD) individuals. The study objectives were to (i) report QOL in ACLD cohorts 5-25 years following ACL rupture, (ii) compare QOL in ACLD and ACLR groups; and (iii) identify factors that may influence QOL outcomes 5-25 years after ACL rupture in ACLD individuals.

**Methods:** We systematically identified and methodologically appraised all studies reporting QOL in ACLD people  $\geq$  5 years following ACL rupture. Knee-related and health-related QOL scores in ACLD and ACLR groups were pooled and compared using a random-effects meta-analysis. Spearman rank correlation coefficient ( $\rho$ ) was used to explore relationships between QOL scores, participant demographics and study characteristics. Descriptive comparisons were made with population norms.

**Results:** Eleven eligible studies reported QOL in 473 participants at a mean 10 (range 5-23) years following non-surgically managed ACL rupture. Knee-related QOL scores from eight studies using the Knee Injury and Osteoarthritis Outcome Score (KOOS) ranged from 54 to 77 (best possible score, 100). This was impaired compared to population norms, and similar or better in comparison to participants treated with ACLR. Knee-related QOL was not related to follow-up duration ( $p=0.55$ ), gender ( $p=0.51$ ) or quality appraisal scores ( $p=0.76$ ). Health-related QOL, measured by the SF-36 in five studies, was similar to population norms, but impaired compared to physically active populations. Meta-analysis revealed no significant differences in KOOS-QOL (mean difference [95% CI], 2.9 [-3.3 to 9.1]) and SF-36 scores (for all SF-36 domains except Vitality) between ACLD and ACLR groups. A range of biases were identified with potential to influence QOL estimates in this patient population, including baseline activity levels, advice regarding activity modification, and surgical treatment of baseline meniscus injuries in ACLD cohorts.

**Discussion:** This systematic review found impaired knee-related QOL in ACLD individuals 5-25 years after ACL rupture compared to population norms. Meta-analysis revealed similar knee-related QOL in ACLD and ACLR groups and no difference in health-related QOL scores for seven of the eight SF-36 domains. This study highlights that longer-term impairments in knee-related QOL are evident after ACL rupture, irrespective of operative or non-operative management. This indicates a need to develop strategies to improve QOL after ACL rupture, and can be used by clinicians to educate patients about realistic long-term outcomes.

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**Background:** Achilles tendinopathy has been identified as one of the most common overuse running-related injuries. Despite many studies of the extrinsic and intrinsic risk factors potentially implicated in the causation of Achilles tendinopathy, few have been shown to clearly either increase or decrease the risk of sustaining Achilles tendon injury. Previous studies have focussed on the association between biomechanical factors and Achilles tendinopathy. In contrast, there is relatively little research focussing on potential biomedical risk factors for Achilles tendinopathy. Biomedical risk factors include medical comorbidities and physiological, biochemical and genetic factors. The purpose of this systematic review is to evaluate studies which investigated biomedical risk factors of Achilles tendinopathy in running / jumping athletes from non-contact sports.

**Methods:** Research data bases MEDLINE, SPORTDiscus and PubMed were searched for literature using relevant terms 'Achilles tendinopathy', 'Achilles overuse injury', 'risk factors', 'athletes', 'runners'. Retrospective and prospective studies were included in the systematic review.

**Results:** A systematic review identified articles suitable for the analysis following selection criteria: specific inclusion of case-control studies on professional and amateur athletes; inclusion of studies where the diagnosis of Achilles tendinopathy was confirmed by a doctor or medical-imaging; studies of biomechanical risk factors were excluded.

**Conclusion:** Due to the multifactorial aetiology of Achilles tendinopathy biomedical risk factors should be considered as potentially important contributors to its development. Further research on the interrelationship between different risk factors may be beneficial for informing the prevention and management of Achilles tendinopathy.

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**Introduction:** The aim of this study is to first evaluate average percentage body weight (APBW) values and weight-bearing distribution percentages (WBDP) between four common sports activities in a referent adult population, and secondly to suggest clinical implications. The study design is an original research study, conducted in the *Lerner Sports Center, Hebrew University, Mount Scopus, Jerusalem, Israel*.

**Methods:** Participants included seventy-five asymptomatic volunteers, mean age = 33.5 (19-72) years SD=15.1, mean weight (kg) = 70.7 (43-113) SD=14.1. Four tests were conducted: 1. Overground walking (OGW) over a 20m distance, 2. Overground jogging (OGJ) over a 20m distance, 3. Treadmill jogging (TJ) at a constant speed of 8.5 km/hr for a 15-second interval and 4. Elliptical exercise (EE) for a 20 second period at a resistance and incline level of 10, and a steady pace within the range of 70-95 steps/min. The main outcome measure used is The Smartstep™ weight-bearing gait analysis system.

**Results:** The APBW value on the entire foot in OGW was 112% (SD=15.57), in OGJ, 201% (SD= 31.24, in TJ, 175% (SD=25.48) and in EE, 73% (SD=13.8). Regarding WBDP, the swing phase in OGJ and TJ was significantly longer than the stance phase ( $p<0.05$ ). OGW resulted in significantly less swing phase compared to OGJ and TJ ( $p<0.05$ ).

**Discussion:** EE significantly reduces weight-bearing as compared to other common functional and sporting activities. These findings may assist the rehabilitation team when considering returning individuals back to early activity following certain bony or soft tissue pathologies or lower-limb surgical procedures. This information is also useful from a repetitive loading standpoint (to prevent overuse injury) or for exercise recommendations for those at greater risk for exacerbating chronic joint pathology.

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**Introduction:** Barefoot running is not a new concept, despite this, relatively few people choose to engage in barefoot (BF) running on a regular basis. Despite the technological developments in modern running footwear, up to 79% of runners are injured every year. While benefits have been proposed, there are also potential risks associated with BF running. The aim of this study is to review the up-to-date evidence-based knowledge concerning barefoot/minimal footwear running and their implications for the practicing physician.

**Materials & Methods:** Multiple publications were reviewed using an electronic search of databases such as MEDLINE, CINAHL, EMBASE, PubMed and Cochrane Databases (from their inception until July 30, 2014) using the search headings: "barefoot running", "barefoot running biomechanics", "shod vs. barefoot running".

**Results:** Eighty-four relevant articles were found. Most were reviews, biomechanical and kinematic studies. There are notable differences in gait and other parameters between barefoot and shod running. Based on these findings, along with much anecdotal information, one could conclude that barefoot runners should have fewer injuries, better performance, or both. Several athletic shoe companies have designed running shoes that attempt to mimic the barefoot condition and, thus, garner the purported benefits of barefoot running.

**Discussion:** Although there is no evidence that confirms or refutes improved performance and reduced injuries in barefoot runners, many of the claimed disadvantages to barefoot running are not supported by the literature. Nonetheless, it seems that barefoot running may be an acceptable training method for athletes and coaches, as it may minimize the risks of injury.

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**Introduction:** Given increasing annual rates of sport-related injuries, the need for effective injury prevention education has become more urgent. This notion was supported in a recent report by the Victorian Sports Injury Prevention Taskforce, with a recommendation to incorporate injury prevention modules/courses in all tertiary sport and recreation related degrees. An important step in the development of effective curriculum is to establish the needs and current knowledge of the learners. Therefore, this study investigated the existing knowledge, attitudes and behaviours in injury prevention and management in students undertaking sport or physical education tertiary degrees.

**Methods:** Ninety-six third year students studying degrees in sport science or physical education at Federation University Australia completed an online, self-report questionnaire. It comprised closed-ended questions that examined students' knowledge of and attitudes to injury prevention and management and some open-ended questions that presented scenarios to establish their predicted behavior in injury situations. Descriptive statistics were conducted using the Statistical Package for Social Sciences (Version 21).

**Results:** Almost a third (30%) had no recognised qualifications in injury management/prevention, for example first aid, sports trainer or different coaching levels. Participants were able to distinguish between injury management and injury prevention and most identified that injury prevention is the responsibility of multiple individuals within sports clubs, schools and active recreation. Half of those qualified and practicing as coaches identified the role of coaches in injury prevention, however, responded that they had not held any role in injury management or prevention to date. When sourcing injury management or prevention information, the majority (81%) would either ask medical professionals or search injury specific websites and felt more comfortable to rely on their current level of knowledge for management rather than prevention of injuries. Most participants (65%) agreed that many sports injuries can be prevented. While the majority concurred that personal protective equipment is effective in prevent injuries, they lacked confidence about the effectiveness of specific pieces of equipment, such as mouth guards. The responses to the injury/risk management scenarios revealed a lack of adequate knowledge or an inability to apply their knowledge to real world scenarios.

**Discussion:** The findings in this study provide valuable information for the development of a national sports injury management and prevention module for tertiary degrees in sport and recreation. Indisputably, an increase in injury prevention education will not only result in safer participation but will also have social and economic benefits at a broader level.

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**Introduction:** Physical and fitness characteristics of the athletes provide distinct advantage in rugby. Over the last two decades, players (both forwards and backs) of the highest performing teams in rugby world cup have become heavier and taller. Therefore, the aims of this study were to evaluate the selected anthropometric and physiological parameters of the Sri Lankan national rugby players and to compare with their international counterparts.

**Methods:** Forty five male rugby players (age = 24.2±3.5 years) from the Sri Lankan national rugby squad (2012/2013 season) were assessed for physical and fitness characteristics. Body mass, height and 4-site skin fold thickness were measured with standard techniques and used to calculate percentage body fat (BF%), lean muscle mass (LMM) and body mass index (BMI). Field tests of physical fitness performance measures including muscle strength and endurance (push-ups and sit-ups), maximum aerobic capacity (Beep test), explosive power (medicine ball throw) and agility (Ilinios test) were measured by standard procedures. Measured variables were compared according to player position (forwards vs. backs) using independent sample t-test ( $p = 0.05$ ).

**Results:** Compared with backs of the present study, forwards were heavier (100.6±20.2 kg vs. 84.6±13.9 kg;  $p < 0.05$ ), taller (179.9±8.8 cm vs. 176.5±7.5 cm;  $p > 0.05$ ), and had higher BF% (17.4±6.7 % vs. 14±5.2;  $p > 0.05$ ) and BMI (31±5.2 kgm<sup>2</sup> vs. 27.1±3.8 kgm<sup>2</sup>;  $p < 0.05$ ). Backs recorded higher maximal aerobic capacity compared to forwards (48.4±5.8 mlO<sub>2</sub>/kg/min vs. 44.9±8 mlO<sub>2</sub>/kg/min;  $p > 0.05$ ). In the other physiological parameters, muscle endurance and agility performance were better among backs ( $p > 0.05$ ), but forwards had significantly better explosive power ( $p < 0.05$ ).

**Discussion:** The positional differences in the measurements observed in the present study were consistent with the literature. Mean values for height and weight of Sri Lankan national rugby players was found to be 10-15% inferior than reported for high ranked international counterparts. Similarly maximum aerobic capacity (VO<sub>2</sub> max) of both forwards and backs were 15-20% lower. Physical and fitness profile of Sri Lankan national rugby players were relatively similar to the profile reported for rugby players from other Asian countries. Despite attaining a higher rank among Asian rugby nations over the last decade, the physical and fitness characteristics of the Sri Lankan rugby players were lower compare to high ranked international counterparts. The genetic factors may accountable for the smaller physique among Asian athletes, which has been a key determinant of rugby performance.

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**Introduction:** Return to sports at pre-injury level is a major concern following anterior cruciate ligament (ACL) reconstruction. There is a relative paucity of data on return to sports among Sri Lankan athletes. Objectives were to identify the percentage of athletes who returned to play (RTP) at their pre-injury level of competition, to identify the risk factors that affect RTP and to quantify the post-reconstruction functional level among Sri Lankan athletes.

**Methods:** 32 male athletes (age = 26.8 ± 3.9 years) undergone ACL reconstruction at National Hospital of Sri Lanka for a period of 3 year were followed up. Participants were interviewed based on a structured questionnaire and data gathered regarding the ACL injury, post-reconstruction rehabilitation and issues pertaining to timing and ability to RTP. Functional knee assessment at post-injury and 1 year post-reconstruction was evaluated using Cincinnati knee rating system.

**Results:** ACL reconstruction was performed 10.8±4.1 months following the injury. Based on the player perception, 53.1% athletes returned to play postoperatively at the pre-injury level. 37.5% return to sports at a lower level and 9.4% were unable to return to play. 68% of athletes who did not return to play in full capacity quoted 'fear of re-injury' as a reason for not achieving full performance. Age, time of surgery, duration of post-reconstruction rehabilitation was not significantly different between those who did and did not RTP. Cincinnati scores at 12 months post-reconstruction between patients who RTP (415±5.16) and those who did not (326±37.7) revealed statistically significant difference (P<0.01).

**Discussion:** RTP rates after ACL reconstruction among Sri Lankan athletes were lower and approximately half of the athletes did not compete at pre-injury level. RTP was within the expected time period of 6-12 months post-reconstruction. Psychological factor such as 'fear of re-injury' was a major cause for not RTP at pre-injury level. Evaluation of the athletes' psychological status and providing support during the rehabilitation phase may provide better outcome in RTP.

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### Beneficial effects of home-based and supervised exercise programs on anthropometric indices, body composition, and aerobic capacity in obese patients who undergoing laparoscopic gastric bypass surgery

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**Background:** The beneficial effects of different exercise protocols on anthropometric indices, body composition, vital signs, and aerobic capacity in patients undergoing bariatric surgery have remained obscure. Hence, the present study aimed to assess the impact of the two types of exercises including home-based and supervised exercise on these parameters in patients who undergoing laparoscopic gastric bypass surgery.

**Methods:** In a randomized clinical trial, 80 consecutive obese patients referred to less invasive surgery ward at Rasool-e-Akram hospital in Tehran that underwent laparoscopic gastric bypass surgery were randomly assigned to schedule supervised exercise therapy (n = 42) or home-based exercise therapy (n = 38). between 2011-2013 The two programs were followed for 6 months and the study parameters were assessed immediately before and also 6 months after the programs.

**Results:** In both groups, the anthropometric parameters, body composition indices including fat percentage, lean body mass, muscular mass, body water rate, and visceral fat significantly decreased, but 6-MWD, oxygen volume, hands muscular power, and also hand power to weight ratio were adversely increased following exercise programs. Although data analysis in our study showed significant changes in all study parameters in both groups scheduled for supervised and home-based exercise programs, more improvement in some parameters including body weight, BMI, fat percentage, fat mass, lean body mass percentage, visceral fat, anthropometric indices, 6-MWD, oxygen volume, heart rate after 6-MWT, and muscular power in both hands was revealed after supervised exercise programs when compared with home-based exercise program. Furthermore, number of footpace at six month after surgery was significantly higher in former group.

**Conclusion:** Scheduling supervised exercise program after bariatric surgery results in more improvement in anthropometric indices, body composition, vital signs, and aerobic capacity in comparison with home-based exercise program.

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### The effects of two different types of footwear on salivary $\hat{I}_{\pm}$ -amylase and IgA levels following 30-min stair ascent and descent in men

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**Background:** Although most kinds of exercise rely on some types of footwear, whether or not different types of footwear have an influence on autonomic activation and immune function after stair ascent and descent remains to be clarified. The purpose of this study was to examine the effects of two different types of footwear (shoes vs. sandals) on salivary  $\alpha$ -amylase and IgA excretion after 30-min stair ascent and descent in recreationally active men.

**Methods:** Ten recreationally active men (age: 20.2±1.0 year; height: 170.4±3.7 cm; body weight: 62.2±4.2 kg; body mass index: 21.6±2.3 kg/m<sup>2</sup>; body fat: 14.3±5.3 %, mean±SD) were recruited in this study. On two different occasions, all participants randomly chose shoes or sandals, completing 30-min stair ascent and descent trials on a stairway.

In the trial, stair ascent was first performed on a stairway consisting of 88 steps with a total vertical displacement of 15 m (each step averaged 17 cm in height) over 8 flights and 5 floors, followed by descent of the same stairs, repeating this cycle (1 cycle: ascent plus descent) for 30 minutes. Each flight was separated by a horizontal connecting platform with a minimum area of 4 m<sup>2</sup>. This trial was undertaken based on a single step ascent and descent (one stair step per stride). Each participant was instructed to ascend and descend at a constant pace of their choice during 30-min so long as it was not too quick to elicit bounding. Moreover, they were instructed not to use handrails or place their hands on their thighs. Unstimulated salivary samples were taken at the 10-min period before (Pre) and after (Post) exercise for the later analysis of salivary  $\alpha$ -amylase and IgA levels which were quantified by an enzymatic assay and turbidimetric immunoassay, respectively.

**Results:** With regard to salivary  $\alpha$ -amylase levels, there was a significant main effect for time (shoes: Pre=357.1±144.2, Post=788.0±268.9; sandals: Pre=483.5±240.2, Post=987.4±572.1 U/mL, p<0.05), but not for types of footwear or interaction. Moreover, no significant main effects for time and types of footwear or interaction (shoes: Pre=10.8±4.9, Post=11.8±6.0; sandals: Pre=11.3±8.3, Post=11.4±3.7 mg/dL).

**Discussion:** Previous research has shown energy expenditure during stair exercise, whereas data has been limited in light of autonomic activation and immune function. The results of the current study indicate that two types of footwear may not have different effects on salivary  $\alpha$ -amylase and IgA levels after 30-min stair ascent and descent at a self-selected pace.

## A comparison of percent change in salivary $\alpha$ -amylase activity after maximal exercise between young athletes and recreationally active adult men

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**Background:** Autonomic nervous system is an important part of the adaptive stress responses. Salivary  $\alpha$ -amylase activity has been regarded as a surrogate biomarker of autonomic nervous system activation after various kinds of exercise in both animals and humans. However, there are limited data available regarding autonomic activity based on salivary  $\alpha$ -amylase excretion after maximal exercise between adolescents and adult men. The purpose of this study was to determine the effects of incremental maximal exercise on salivary  $\alpha$ -amylase in young athletes and recreationally active men matched for aerobic fitness.

**Methods:** Eight young alpine ski athletes (age: 14.0 $\pm$ 0.9 year; height: 162.1 $\pm$ 7.3 cm; body weight: 49.1 $\pm$ 7.9 kg; body mass index: 18.6 $\pm$ 1.5 kg/m<sup>2</sup>; body fat: 11.3 $\pm$ 4.2 %; peak oxygen uptake: 54.7 $\pm$ 7.0 mL/kg/min) and eight recreationally active adult men (age: 20.6 $\pm$ 0.5 year; height: 169.5 $\pm$ 5.0 cm; body weight: 64.0 $\pm$ 7.0 kg; body mass index: 15.5 $\pm$ 3.3 kg/m<sup>2</sup>; body fat: 22.3 $\pm$ 2.2 %; peak oxygen uptake: 54.6 $\pm$ 3.1 mL/kg/min, mean $\pm$ SD) were recruited in this study. All participants carried out an incremental cycling exercise until volitional exhaustion to obtain peak oxygen uptake on an electromagnetically braked cycle ergometer. Each participant performed a cycling exercise at an initial power output of 0 W for three minutes, which was increased by 25 W every 1-min with 60 rpm of pedaling frequency until exhaustion. Expired gases and heart rate were continuously determined using a respiratory monitor system and electrocardiograph. Unstimulated salivary samples were taken at the 10-min period before (Pre) and after (Post) exercise for the later analysis of salivary  $\alpha$ -amylase levels which were determined by a biochemical assay.

**Results:** There was a significant main effect for time (Pre vs. Post,  $p < 0.05$ ), but not for group (young athletes vs. adults) or interaction. On the other hand, significantly lower percent changes in salivary  $\alpha$ -amylase activity were found after maximal exercise in young athletes compared to recreationally active adult men (young athletes: 79.2 $\pm$ 82.6; adults: 401.4 $\pm$ 347.8 %,  $p < 0.05$ ).

**Discussion:** Understanding autonomic nervous system activation in young athletes is critical in adolescence given developmental changes. However, few data are available in young athletes despite of a growing evidence of the relationship between salivary  $\alpha$ -amylase activity and exercise in adults. The main findings of the current study suggest that percent change in salivary  $\alpha$ -amylase activity following maximal exercise appears to be lesser in young athletes than in men due to the differences of the activating autonomic reaction.

## The maximal effort swimming change the salivary cortisol and testosterone concentrations in saliva

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**Introduction:** The purpose of this study is to determine the change of salivary cortisol and testosterone concentrations when the athletes swam in a peak load. To achieve a peak load, we gradually increased the load. It is reported that the change of cortisol concentrations in saliva fluctuates by the stress. Thus, we consider whether salivary cortisol and testosterone changes are effective for an index of the training.

**Methods:** We intended for 24 (male:14, female:10) university students who participate in an intercollegiate championship in Japan. All participants swam 200m free style 4 times (best time +40 seconds, +30 seconds, +20 seconds, maximal effort). We measured cortisol and testosterone concentrations in saliva, HR(heart rate) and lactic acid values at rest pre-swimming period (PS), later three times of attempts, maximal effort swimming (MES), 20, 40 and 60 minutes later after MES.

**Results:** The salivary cortisol levels ( $\mu$ g/dl) were at PS (male 1.11 $\pm$ 0.01, female 1.12 $\pm$ 0.02), at the just after MES (1.13 $\pm$ 0.01, 1.14 $\pm$ 0.02: both male and female  $p < 0.01$  VS PS), 20 minutes (1.15 $\pm$ 0.04, 1.16 $\pm$ 0.01: both male and female  $p < 0.01$  VS PS), 40 minutes (1.14 $\pm$ 0.03, 1.16 $\pm$ 0.03: both male and female  $p < 0.01$  VS PS), 60 minutes after MES (1.13 $\pm$ 0.02, 1.16 $\pm$ 0.03: both male and female  $p < 0.01$  VS PS) and reached to the peak value after 20 minutes later the MES. The testosterone levels (pg/ml) at PS were (1.7 $\pm$ 0.03, 1.77 $\pm$ 0.03), 20 minutes after attempts (1.66 $\pm$ 0.04, 1.73 $\pm$ 0.04: both male and female  $p < 0.01$  VS PS). The pulse rates and the lactic acid levels increased with an exercise loading and showed the maximum just after MES.

**Discussion:** The Cortisol and testosterone were considered to be stress hormone in saliva fluctuated by maximal effort swimming, and it is the new finding that the maximal effort swimming exercise changes the salivary stress hormone cortisol and testosterone. However, two hormones level did not show a correlation between a pulse rate and blood lactic acid level. That the change of these two hormones reflects the stress caused by exercise test will be a future problem in future.

## The effect of backpack carriage on the biomechanics and neuromuscular control of locomotion: a systematic review and preliminary meta-analysis

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**Introduction:** Load carriage is an essential mode of object transportation in sports and occupations. Heavy load carriage is associated with reduced physical performance. Understanding the key neuromechanical changes during load carriage is important in identifying the key factors that drive altered physical performance. No review studies have systematically analyzed the literature to identify consistent biomechanical and neuromuscular changes during load carriage.

**Methods:** A comprehensive search of electronic databases from inception till 30th April 2014, with till 31st June 2014, were reviewed. Trials evaluating the impact of symmetrically carried posterior load carriage systems only on healthy adults, on the kinematics, kinetics, spatio-temporal and electromyographic activity during level walking, level running, and jump-landing tasks were included. Two independent reviewers evaluated both the

quality of reporting and risk of bias in all included studies. Meta-analysis was completed where possible based on available reported data, whilst a qualitative review of the evidence was completed when data pooling was not possible.

**Results:** 48 studies were identified, all performed on load carriage walking. Meta-analyses were possible for kinematic, kinetic and spatio-temporal variables. Pooled data indicate that load carriage was associated with an increase in hip (SMD = 3.13) and ankle excursion (SMD = 0.82). Load carriage was associated with an increase in vertical and horizontal ground reaction force parameters (SMD = 1.69 to 3.23). Spatio-temporal variables that significantly changed with load include an increase in walking cadence (SMD = 0.25), reduced stride length (SMD = -0.21), increase in double support duration (SMD = 0.67 to 0.99) and reduced single support duration (SMD = -0.49). Qualitative synthesis of electromyographic changes with load carriage points to an increase in triceps surae and vasti muscle activation amplitude.

**Discussion:** Load carriage results in some consistent kinematic, kinetic and spatio-temporal changes during walking. Interpretation of these findings from energetics and modelling studies highlights important neuromechanical adaptations to load carriage. Walking performance likely deteriorates when the neuromechanical control of gait no longer positively adapts to increasing load. An important limitation of this review is the unclear risk of bias of most studies which preclude clear evidence from being drawn about the effects of load carriage on walking biomechanics. In addition, the effects of load carriage on running and jump-landing tasks have been poorly studied. Future studies should look into the role of load carriage on running and jump-landing based tasks, and include more robust reporting and methodology.

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### Social Media and UNSW Sports Medicine Society: A new face in Sports and Exercise Medicine

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**Introduction:** The University of New South Wales Sports Medicine society (UNSW SportsMedsoc) is a non-profit student organisation founded in 2014, aiming to increase exposure of Sports and Exercise Medicine (SEM) as a medical specialty; improve SEM education at UNSW; and provide opportunities for medical students to be involved with SEM. Social media is an integral part of this mission, allowing content creation, collaboration and sharing of SEM content between vast numbers of students over various platforms. A recent survey by Townsend et al (2013) reported that over 99% of Australian medical students currently utilise Facebook for educational purposes, in contrast to the <10% of Australian clinicians. Run by students for students, UNSW SportsMedsoc sought to capitalise on this, combining traditional promotional methods with social media as a cost effective and suitable method of engaging our target audience.

**Methods:** Traditional methods of recruitment including shout-outs, face-to-face meetings and educational events were supplemented with extensive recruitment and discussion on social media platforms including Facebook, Twitter, Google Suite of Applications and live-streaming (Google Hangout and YouTube). Cross-promotion with relevant groups such as UNSW Medical Society and New South Wales Medical School Council furthered our reach. Infographics, digital posters and photographs were used to increase virality.

**Results:** Since the launch of UNSW SportsMedsoc there has been substantial improvement in awareness of SEM at UNSW and across the medical student population. In less than 3 months since its creation in February 2015, the UNSW SportsMedsoc Facebook Page has reached 340 "likes", with no financial outlay. "Fans" of the page range from Australia, USA, Brazil and the UK. Over this time period, average reach has been 141 people per day by the page, 242 people per photo post, 212 people per shared external link and 139 people per status. 19,000 people were reached by the link for our first Facebook event, "Introduction to Sports Medicine" with 1,000 people viewing its content and 212 engaged online. Subsequent tweeting and re-tweeting of this event has resulted in international collaboration.

**Discussion:** Our findings demonstrate the power of utilising social media as an adjunct to traditional recruitment and education methods in engaging SEM with medical students in Australia and around the world. This is consistent with current trends. As the uptake of social media increases in the working medical profession, the investigators expect that the utility of social media in medical education and promotion of SEM will only increase further.

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### Is cholesterol associated with altered tendon structure or tendon pain? A systematic review

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**Background:** Adiposity has been shown to have an association with tendinopathy, and individuals with Achilles tendinopathy have a dyslipidaemic profile. Extreme cholesterol levels in familial hypercholesterolaemia are associated with a 6-fold increase in Achilles tendon pain prevalence. Our objective was to investigate whether there is an association between cholesterol and tendon structure or tendon pain in those with high cholesterol of non-genetic cause.

**Methods:** We conducted a systematic review and meta-analysis. Relevant articles were found through an electronic search of six medical databases – Medline, Cochrane, AMED, Embase, Web of Science and Scopus. We included all case-control or cross-sectional studies with data describing both i) lipid levels or use of lipid-lowering drugs and ii) tendon structure or tendon pain.

**Results:** Seventeen studies (2612 participants) were eligible for inclusion in the review. People with altered tendon structure or tendon pain had significantly higher total cholesterol, low-density lipoprotein and triglycerides, as well as lower high-density lipoprotein; with mean difference values of 0.66, 1.00, 0.33, and -0.19 respectively.

**Discussion:** The results of this review indicate that a relationship exists between an individual's lipid profile and tendon health. However, further longitudinal studies are required to determine whether a cause and effect relationship exists between tendon structure and lipid levels. This could lead to advancement in the understanding of the pathoetiology and thus treatment of tendinopathy.

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**Background:** The elite athletes must keep good balance during a competition. A swimmer needs highly balance ability. In sports activity, it is important that muscular strength is coordinated as well. In particular, muscle coordination during aquatic sports (swimming, water polo, synchronized swimming) were most important factor to improve human performance. The purpose of this study was to examine the balance ability in elite athletes.

**Methods:** Twenty-three female swimmers (international elite level and junior international level) participated in this study. Postural sway was measured by a piezo-electric force platform (9281E, KISTLER, Swiss). To measure the balance ability, the center of pressure (COP) displacement of the ground reaction force was recorded at a frequency of 20 Hz while the subjects were taking static standing position with opened eyes or closed eyes on the force platform for 30 seconds. The total length of COP displacements (LNG) and total movement area of COP (Environmental area: ENV. area, Rectangle area: REC. area) were calculated as an indicator of the balance ability.

**Results:** The elite athletes were more superior in the total length of COP displacements (elite: Open eye LNG: 26.15±7.96cm, Closed eye LNG: 36.32±11.36 cm, junior: Open eye LNG: 30.48±7.43 cm, Closed eye LNG: 36.04±10.35 cm). The total area of COP displacements (ENV. area) showed 0.91±0.60 cm<sup>2</sup> (elite) and 1.39±0.77 cm<sup>2</sup> (junior) in open eyes static standing position. The total area of COP displacements (REC. area) showed 2.29±1.48 cm<sup>2</sup> (elite) and 3.83±2.56 cm<sup>2</sup> (junior) in open eyes static standing position. Average values and SD of percentage of center of gravity (anatomical posture) and percentage of center of gravity (both hand-up posture) were 53.3±0.8% and 57.0±0.7%, respectively.

**Discussion:** The elite athletes had a short LNG in comparison with the normal student. In addition, the LNG in open eyes standing position was significantly shorter in the elite athletes than in the junior athletes. On the other hand, there was no significantly difference in the LNG during closed eyes. It is clear that the elite athletes had high balance ability during the static standing position.

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The negative impact of injury on the elite athlete to participate and perform is well known. As a result, researchers are focusing on injury prevention strategies for a number of musculoskeletal injuries such as hamstring injury and anterior cruciate ligament rupture. To date, little research has been conducted on the prevention of lower limb tendinopathy.

The first step in developing injury prevention strategies is to establish the extent of the problem. In football these data are limited as only games missed per club are recorded. However, this does not account for athletes that are continuing to participate in games and training, yet at a reduced volume and affecting performance. For lower limb tendinopathy, these data collection methods are missing the problem. This presentation will discuss a number of outcome measures that may be utilised in future.

The mechanisms of injury and the risk and associated factors such as age, sex, genetics, body composition, tendon abnormalities and biomechanics have all been shown to be factors related to tendinopathy. However, the majority of these factors are non-modifiable or of little relevance to the athletic population. Clinically, load is critical to the development of tendinopathy yet specifics around this are yet to be elucidated (ie types of loading, frequency etc).

This presentation will discuss the future of injury prevention for tendinopathy using better suited outcome measures, the critical risk factors in the development of tendinopathy and the future direction of injury prevention strategies. It is important to note that the greatest risk factor for increased tendon morbidity in the elite athlete is a history of previous injury. Not only are strategies needed to prevent the development of tendinopathy, but also minimise the impact and burden of tendinopathy in those that already have pain yet are still participating in training and games.

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**Introduction:** Many physical activity programs have successfully used step counting pedometers to increase program compliance and effectiveness. However a range of advanced electronic trackers that measure physical activity 24 hours per day have recently emerged. There is little understanding of how people use these new trackers and what their preferences are. This information is necessary for researchers and public health professionals to successfully utilize the available trackers to improve the effectiveness of future physical activity interventions.

**Methods:** The current study measured Australian's attitudes, intentions and preferences for using physical activity trackers through CQUni's 2014 National Social Survey. Descriptive statistics were used to report the findings, and logistic regression was used to determine whether physical activity levels, BMI, age and gender significantly influenced the likelihood of tracker use.

**Results:** A total of 1349 Australians participated in the survey. The mean age of the sample was 54 years, and 49% were males. Over one third of participants (35%) had used a tracker. A logistic regression analysis (n = 1325) revealed that Males were less likely to have used a tracker (OR= .61, 95% CI .48-.77), and the likelihood of tracker use increased with physical activity minutes per week (OR= 1.01, 95% CI 1.0-1.01), and decreased with age, (OR= .99, 95% CI .98-.99). The most frequently used tracker was a pedometer (59%); the use of heart rate monitors, accelerometers and smart phone applications was relatively even (13%, 12% and 17% respectively). A quarter (24%) of those who had never used a tracker were interested in using one. Over half of all respondents (53%) would prefer to wear a tracker on their wrist. 31% indicated that counting steps is the most important function, and 30% indicated that accuracy is the most important characteristic. The most selected reasons for not wanting to use a monitor was, 'I don't think it will help' (39%), and 'I don't want to increase my activity level' (47%) rather than cost, technology or time reasons.

**Discussion:** These findings reveal that a moderate percentage of Australians are likely to be interested in using a physical activity tracker, with females, younger people, and people with higher levels of physical activity more likely to use a tracker. To increase tracker use programs should address the barrier of participants not believing that trackers will help their activity, and should use trackers which can be worn on the wrist, can measure steps, and are accurate.

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### Footwear related pain and running related injuries

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**Introduction:** Running related injuries are often multifactorial and can impact on the level of participation and performance. Pain associated with footwear design and the development of running related injury is a modifiable risk factor. Therefore the primary aim of this survey was to investigate participant perceived comfort of their footwear and prevalence of running related injuries. Secondary aims included an evaluation of health professionals sought per injury type, and risk of injury associated with mileage, running surface and demographic characteristics.

**Method:** This was a retrospective descriptive epidemiological survey of recreational runners. Participants were recruited from the University of Newcastle and the Central Coast community. Participants had to run a minimum of twice per week to be included. Participants attended a single session at the University of Newcastle where they completed a survey about the effect of running shoe design on comfort and injury rates.

**Results:** One hundred and ninety-five participants (M=112) completed the survey. Mean age (37.26; SD 14.21; range 18-78 years), BMI (22.28; SD 2.02), and mileage per week (32.36km; SD 19.42) were calculated. Eighty two wore motion control footwear, 91 neutral footwear, 22 barefoot-style footwear, and 1 did not wear shoes. The road (n=100) was the most commonly reported running surface. One hundred and nine participants reported experiencing pain when running during the previous three months with the most common area affected being the knee (n=25). In the last three months, 45 runners had at least one running related injury diagnosed by a health professional, most commonly by a physiotherapist, general practitioner or podiatrist. Twenty-six reported that in the last three months they had experienced pain and discomfort they considered to be directly associated with their footwear (n=10 [motion control footwear]; n=14 [neutral footwear]; n=2 [barefoot-style]). Regression analysis was performed and increased likelihood of a diagnosed injury at any site was found to be significantly related to the presence of footwear related pain or discomfort (OR 1.51,  $p=0.03$ ) and with increased weekly mileage (OR 1.14,  $p=0.001$ ). Conversely, running on surfaces other than the road reduced the likelihood of injury (OR 0.48,  $p=0.05$ ).

**Discussion:** Clinical evaluation of recreational runners should involve a thorough investigation of mileage, footwear related pain, and whether or not they run on road because each is associated with increased likelihood of injury. Future research investigating footwear related pain and running related injuries should be prospective cohort studies in order to establish a cause-and-effect relationship.

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### Equity in single-sex sport for adolescents: Should psychological differences be considered?

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**Background:** Legal challenges to single-sex netball in Australia, frequently involve adolescents. In addition to controversies surrounding physical changes in adolescence, psychological differences may also be significant. Psychological sex-related differences may relate to how sports participation influences physical-self perceptions and attitudes to training and competition, even in low contact sports such as netball. The aim of this study was to compare two groups of adolescent males and females, representing early and mid-late adolescence for differences in physical self-perceptions and attitudes to mixed-sex sporting competition.

**Methods:** A relatively active sample (83% playing sport outside school) of early (Year 7 of secondary school, aged 12.0-13.1 years; N=32 males, 54 females), and mid-late (Years 8 & 9 of secondary school, aged 13.3-15.9 years; N= 65males, 57 females) adolescents, volunteered from a convenient sample of three secondary schools. Adolescents completed a modified Physical-Self Questionnaire and provided responses to open-ended questions on mixed-sex sport. Correlations between hours of sports participation and attributes of physical self were generated within sex and adolescent group.

Responses to open ended questions were collated into positive, negative or neutral categories.

**Results:** Hours of sports participation (median 3 – 4.5 hours per week outside school) were not associated with physical attributes in early adolescent males and only modestly associated ( $r = 0.48$ ) with perceptions of being good at physical activity in their female peers. Among mid-late adolescents, hours of sports participation was similarly and modestly related to perceptions of being good at physical activity in males ( $r = 0.48$ ) and females ( $r = 0.56$ ). However, other attributes of the mid-late adolescents differed. Specifically, sports participation was modestly associated with self-esteem, strength and endurance in males, and coordination and flexibility in females. Overall, the number of physical attributes associated with hours of sports participation was greater and showed stronger male/female differences in mid-late adolescents than in early adolescents. Positive attitudes to mixedsex sporting competitions were described by 58% of males and 64% of females; with 16% of both sexes describing the notion as negative.

**Discussion:** In contrast to early adolescent responses, in mid-late adolescents, hours of sports participation generated some clear differences in perceptions of physical-self attributes. Despite, the majority of male and female adolescents perceiving mixed-sex competition as positive; there were 16% for whom the notion was negative. The data support the case for the consideration of psychological differences when single-sex competition is debated for older adolescent males and females.

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**Background:** Many studies have documented an association between chronic low back pain (LBP) and diminished muscular performance capacity. However, few studies have quantified the changes in these measures following interventions using objective measurement techniques or related them to changes in clinical outcome. A previous study compared the effects of active physiotherapy, muscle reconditioning devices, or low-impact aerobics on back muscle function in LBP patients. Significant changes in muscle performance were observed in all groups, due to changes in neural activation of the lumbar muscles and psychological changes such as pain tolerance. Given the impact of pain tolerance on muscle performance, we aim to assess movement and EMG muscle activity before and after a pain relieving nerve block. The aim of this study is to document the changes in movement, posture and muscle activation patterns following medial branch blocks (MBB) for facet joint related back pain, and sacroiliac joint (SIJ) injection for sacroiliac joint related back pain.

**Methods:** The ViMove DorsaVi motion sensor was used to measure movement in three planes (Flexion, Lateral Flexion and Rotation), muscle activity around the lumbar spine and vibration affecting the lumbosacral region. Patients (n= 9) (a series of 80 patients will be presented at the conference) undergoing medial branch blocks for facet joint related back pain (n=5) or sacroiliac joint block injections for sacroiliac related back pain (n=4), underwent ViMove assessment prior to and 30 minutes following their nerve block procedure. Pain, pre and post block was measured using the numerical pain rating scale (NPRS). Data collected was IRB approved and statistical analysis performed.

**Results:** Following the nerve blocks, pain reduced by a mean  $5.7 \pm 2.4$  NPRS ( $7.5 \pm 1.7$  vs.  $2.0 \pm 2.2$ ,  $p < 0.05$ ). Overall, lumbar flexion EMG activity was reduced post nerve block in 5 patients, whilst activity levels remained similar for 3 patients. Only 1 patient resulted in increased activity, however, this patient still reported high pain relief following their block. Type of block was not a factor in determining change to EMG activity. Both groups observed a trend in improved range of movement, in both lateral flexion and extension planes. A trend suggesting a reduction in pelvic tilt in the SIJ block patients compared to minimal changes in the MBB was also reported.

**Discussion:** These early stage results indicate a possible interaction between pain relief, range of lumbar movement and lumbar flexion EMG activity, suggesting that pain tolerance may positively impact on muscle performance.

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**Introduction:** Intra-pelvic (pelvic girdle) instability has been associated with lumbo-pelvic pain but controversy prevails over identifying and linking aberrant movement to pain. Current examination for intra-pelvic stability uses palpation of bony landmarks as the patient moves but currently has controversial reliability and therefore validity. Here, we will investigate the utility of a series of small, wireless motion sensors to measure pelvic movement and objectively determine intra-pelvic instability.

**Methods:** The ViMove (dorsaVi) motion sensor system, designed to measure lumbar motion relative to the sacrum was investigated for adaptation to measure relative innominate motion in asymptomatic normal volunteers and symptomatic sacroiliac joint pain patients. We assessed adapting the positioning of the sensors to measure relative innominate motion.

**Results:** Motion testing for left versus right symmetry of innominate bone movement was performed by skin-surface placement of inertial sensors over right and left PSIS during a trunk flexion movement. A series of three movements were repeated. Motion sensor data was recorded independent to tester observation. Using this technique, it was possible to measure maximum flexion of the left and right innominate, along with calculate the difference between the two. Furthermore, it was determined that EMG activity could be reliably measured. A case series of normal asymptomatic participants (n=15) and sacroiliac joint pain patients will be available at the conference.

**Discussion:** Despite widespread acceptance amongst experienced clinicians, the concept of intra-pelvic instability remains controversial in the wider medical community. Hence, lack of a validated objective outcome measure for intra-pelvic instability has major impact on access to treatments for these patients and has made research in the area difficult. Thus, a tool that simply and reliably measures intra-pelvic instability will provide invaluable insight into this diagnostically difficult patient population.

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It can be difficult for the clinician to differentially diagnose, and identify the key nociceptive contribution to, anterior knee pain (AKP). The most commonly involved structures in non-traumatic presentations of knee pain are the patellofemoral joint and patellar tendon. Wasting of the quadriceps and/or impaired motor control are seen in the clinical presentation of both conditions but it is not known if these clinically similar conditions have comparable corticospinal control of the quadriceps.

Current approaches for managing AKP would be improved with a better understanding of the local and central contributors to pain and dysfunction. Treatment directed solely at local contributors have had variable results, with exercise based therapy directed towards the quadriceps the most effective rehabilitation. An understanding of the corticospinal control of the quadriceps may improve treatment outcomes and demonstrate the similarities or differences in various AKP presentations.

This presentation will present data demonstrating that there are differences in the cortical control of the quadriceps (excitability and inhibition) in patellar tendinopathy compared with other AKP presentations and provide a clinically relevant toolkit for differential diagnosis of anterior knee pain. The clinical implications of these findings in terms of both the differential diagnosis and considerations for rehabilitation will be discussed.

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### Refinement of agility tests for leg function

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**Introduction:** Researchers and clinicians have used varying combinations of both field and lab based agility tests as performance and clinical measures. These tests look to replicate agility movements seen in sporting activities. However, limitations exist in the test methodology, scoring criteria and in the tests' ability to distinguish between high and low performances. This study aimed to develop new protocols for the Hexagon Hop and Hop-and-Hold tests, aimed at increasing test sensitivity to change, and to determine test reliability and validity for current and refined protocols of these tests,

**Methods:** 20 healthy general public members (mean age (SD) 23 yrs  $\pm$  5, height 174 cm  $\pm$  10, weight 71 kg  $\pm$ 10) were tested on three separate occasions (Day One, Two (24 hours) and Seven (one week)). On each occasion participants were randomized to complete both current and refined testing protocols for the SL Hop for Distance, Hop-and-Hold (3-pronged Vs Cross), and Hexagon hop Vs Square Hop to determine test reliability and validity. Reliability was determined as low, moderate or high according to previously published criteria.

**Results:** The new tests (Square Hop and Hop-and-Hold (Cross), showed an increased score range and significant correlations ( $p=0.05$ ,  $0.01 - <0.001$ ) when compared to their previously established counterparts (Hexagon and Hop-and-Hold (3-Pronged)). Both current and refined test protocols reported moderate or high reliability; SL Hop for Distance ICC = 0.98 – 0.99; Square Hop ICC = 0.82 – 0.86; Hexagon Hop ICC = 0.75 – 0.88; Hop-and-Hold (3-Pronged) = ICC 0.65 – 0.86 and Hop-and-Hold (Cross) ICC = 0.62 – 0.76.

**Discussion:** The new tests are as reliable as the current versions, and show less evidence of learning effects between testing sessions. Significant correlations between the new and original version of the tests suggest that the new tests are measuring similar skills and can be used in similar testing contexts as the original protocols. However, the new protocols have a wider range of scores, which may enable a greater sensitivity to change in repeated or comparative cohort testing. The original protocols typically produced scores with absolute values close to 10, rendering changes in score of less than 10% clinically un-measurable. The new protocols produce scores well in excess of this, perhaps broadening their potential to reveal meaningful changes in agility test performance. Additional research is recommended to further evaluate the role of agility in performance and injury, using these more sensitive protocols.

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### Reliability of hopping-based agility tests: A systematic review

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**Introduction:** A number of field and lab based tests are currently in research and fitness training to assess agility. These tests are used as performance measures and diagnostic assessment tools. Researchers and clinicians have used varying combinations of double leg (DL) and single leg (SL) agility hopping tests for these assessments; to establish baseline performance measures and to aid in decisions regarding ongoing treatment. Due to the extensive number of tests reported in the literature, there is a need to clarify which tests, or combinations of tests are most reliable and valid for different purposes. This will enable clinicians to make an educated decision regarding test selection. This study reviewed the current literature relating to commonly used DL and SL hopping tests, to provide clinicians with an understanding of how best available tests can be used in their current forms.

**Methods:** A search of PubMed, MEDLINE and SPORTDiscus bibliographical databases for biomedicine was performed. Papers satisfied inclusion criteria if; sample was from an adult population; presented their own reliability and test methodology for; 1) SL Horizontal hop; 2) SL Vertical Hop; 3) triple hop for distance; 4) cross over hop; 5) 6-Meter timed hop; 6) hexagon hop and; 7) square hop.

**Results:** 27 papers were deemed to meet the eligibility criteria and included in the present study. Reliability varies across all the tests reviewed: SL Vertical Hop (n=9) ICC = 0.22 – 0.97; SL Horizontal Hop (n=15) ICC = 0.58 – 0.99; Triple Hop for Distance (n=9) ICC = 0.88 – 0.98; Cross-Over Hop (n=10) ICC = 0.84 – 0.98; 6-Meter Timed Hop (n=9) ICC = 0.60 – 0.96; Hexagon Hop (n=3) ICC = 0.66 – 0.99 and Square Hop (n=3) ICC 0.55 – 0.90.

**Discussion:** SL Hopping tests in a single plane of motion show greater and more consistent reliability than compared to multidirectional test across varying population groups. However, inconsistencies in test methodology make comparisons, appropriate test selection and application difficult. If implementing pre-established tests, clinicians should look to establish their own tester reliability, and have an understanding of the impact of learning effects on performance when scheduling repeated testing. Future research focusing on the development of standardised protocols and reliability for a battery of tests that assess multiple planes movement as well as rotational stressors is recommended.

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### A comparison of physical activity and sedentary behavior in nurses who work night and day shifts

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**Introduction:** In order to meet the increasing demands of the 24/7 needs of the healthcare sector, many nurses work shifts. Previous research has shown that shift workers have poorer health-related lifestyle behaviours and fewer opportunities for physical activity (PA) than non-shift workers. Therefore the aim of this research was to compare habitual levels of PA and sedentary behaviour (SB) in nurses who work either day or night shift.

**Methods:** The research was conducted in three public hospitals in Cape Town, South Africa. All nurses were eligible to participate, irrespective of rank or qualifications. They worked either day shift (07h00 to 19h00), or night shift (07h00). Participants completed a socio-demographic

questionnaire where they reported on their health status, marital status, education and current shift work. The nurses wore the Actigraph GT3X accelerometer for 7 consecutive days, with a minimum of 4 days of data, (including 3 workdays and 1 non-work day, and at least 600 minutes per day), being required for statistical analysis. Time spent in sedentary, light, moderate and vigorous intensity PA on work and non-work days was calculated. Differences between PA and SB on work and non-work days for the two shifts were analysed using analysis of variance.

**Results:** Most of the participants were female and the day shift nurses ( $n=80$ ) were significantly younger than those who worked night shift ( $n=81$ ),  $41.2 \pm 11.3$  versus  $45.1 \pm 11.0$  years. The mean number of days for those with valid accelerometer data ( $n=120$ ) was  $5.4 \pm 1.5$  days and average wear time was  $929.5 \pm 121.1$  minutes per day. Movement patterns were quite similar in the two groups, especially on non-work days. On average, 96% of the nurses' time was spent in SB and light intensity activities, on both workdays and non-work days. However, on workdays the night shift nurses spent slightly less time sedentary (56%) than the day shift nurses (60%,  $p=0.02$ ), and slightly more time in moderate intensity PA (3.5%, compared with 2.4%;  $p=0.01$ ).

**Discussion:** Despite having an occupation that is perceived to require continuous light intensity PA, both night and day shift nurses spent more than half their time in SB on workdays.

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## Blood Pressure Responses to Immersion and Hypertension – a Consideration for Water Exercise

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**Background:** Water exercise has many health benefits and is often recommended for overweight people due to the decreased load on the joints. However many overweight people also have hypertension and the effects of immersion on the cardiovascular system may impact on the suitability of this form of exercise for this population. The magnitude of these effects is both depth and temperature dependent. Therefore the purpose of this study was to examine the effects of upright standing immersion in water at 27°C, a temperature used in climate controlled pools, on blood pressure measures in normotensive individuals and those with prehypertensive/hypertensive conditions.

**Methods:** Twenty eight participants, 16 males and 12 females, with a mean age of 38.4 (SD 11) years, and mean BMI 26.2 (SD 4.6) kg/m<sup>2</sup> volunteered and were grouped as normotensive (N,  $n=19$ ) or prehypertensive/hypertensive (H,  $n=9$ ). Participants in the prehypertensive/hypertensive group were not taking medication for blood pressure control. Blood pressure and heart rate were measured during standing on land and following upright immersion to the mid chest height in water at 27°C. Measures were taken at four time points (2, 9, 12 and 19 minutes) to investigate the effects of time on blood pressure.

**Results:** The results of the two way repeated measures ANOVA (condition x group) on the mean values in both land and water conditions indicated there were significant ( $p < 0.05$ ) increases in systolic pressure ((N) land 111 mmHg to water 118 mmHg; (H) land 132 mmHg to water 142 mmHg) and diastolic pressure ((N) land 63 mmHg to water 67 mmHg; (H) land 79 mmHg to water 86 mmHg), and a decrease in heart rate ((N) land 77 bpm to water 63 bpm; (H) land 76 bpm to water 66 bpm) from land to water immersion. Both systolic and diastolic pressures were highest and heart rate was lowest at the first time point, in both groups, following immersion. There were no significant group x condition interactions.

**Discussion:** The results of this study indicate while the magnitude of increase in blood pressure was similar between groups the increase in pressure in hypertensive groups may warrant consideration when designing exercise interventions. The current study employed stationary immersed conditions, the addition of exercise and the potential effects of medication used to control blood pressure may further impact on the observed responses.

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## Head knocks matter: Early findings from the 2015 football self-report injury study.

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**Introduction:** Australian Rules Football (AFL) has one of the highest injury rates in Australian sport. The AFL Injury Report records an injury if a player misses a week of play, hence injuries that do not meet this criteria may not be captured. In the Western Australian Football League (WAFL) there is no uniform manner of collecting injury data. Injury self-reporting by players is uncommon, yet previous research indicates a higher incidence of injuries, specifically concussions, are recorded when self-report methods are used. This study reports the reliability of the self-report injury tool and six weeks of data. It is part of the larger study that examines the incidence of self-report injury over the 2015 WAFL season.

**Methods:** An anonymous Self-Report Injury Survey including post-concussion symptoms items was piloted with players ( $n=40$ ) from one WAFL club to assess reliability. The survey development involved an expert panel, five WAFL player's input and feedback from players during the pilot phase providing face and content validity. The resulting survey was completed fortnightly by players ( $n=78$ ) from one WAFL club. Data was analysed using SPSS version 22. Due to the 'snap shot' nature, only descriptive statistics were derived.

**Results:** Strong test-retest reliability was established for the eight injury items. Percent agreement ranged from 95% to 100% with no significant differences between test and re-test scores ( $p > .16$ ). The post-concussion symptoms items were also reliable with all 32 items scoring percent agreement of 92.5% to 100% with 29 out of 32 items reporting a Kappa greater than .640. The highest self-report injury was groin and lower limb; followed by head, neck and face contact; back trunk and upper limb then diagnosed concussion. Eighty three percent of those who reported concussion and/or head knocks also reported at least one post-concussion symptom. The most frequently occurring symptoms were headache, sleep disturbance, fatigue and forgetfulness. Poor concentration was the most frequently identified ongoing symptom.

**Discussion:** The results support previous research that indicates self-report tools are a reliable way of gathering injury data. The results also indicate players reported post-concussion symptoms associated with head, neck and face injuries in addition to diagnosed concussions. This supports research from other sports that report post-concussion symptoms can result from head knocks. Given the prevalence of head knocks were greater than concussion, self-report should be considered as a tool to assist with the diagnosis and treatment of these injuries in a sporting environments.

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**Introduction:** A core challenge for those training to deliver sport psychology is the clear demonstration of competencies for external reviewers. Likewise, the ethical promotion of services, and their evaluation by recipients, requires a clear understanding of what sport psychologists actually do. Current literature regarding applied sport psychology focuses on specific and isolated aspects of the role: prioritising some considerations (e.g., needs analysis and intervention selection) and neglecting others (e.g., case formulation, philosophy and planning of service delivery). This paper argues that there are clear benefits to capturing all aspect of the sport psychologist's process in one model, and demonstrating the interactions and dependencies between each task/role.

**Method:** The auto-ethnographic experiences of a registered psychology practitioner, approved supervisor, assessor/reviewer and research of applied practice were incorporated into a working model. The model was developed, recursively, over a 5-year period, through processes of reflective practice and using 'critical friend' reviews from experienced peers. The resulting model – along with an account of its development – is presented and the key predictions, impacts and benefits/risks are reviewed.

**Results:** A model is proposed spanning the sport psychologist's process from beginning to end. Foundational considerations include (a) ethics; and (b) philosophy of practice. Built upon these foundations, a sport psychologist typically performs: (c) an intake; (d) needs analysis; (e) case formulation; (f) choosing of support-strategy; (g) planning the support; and (h) delivering and monitoring the support to completion. Overlaying these processes is (i) an overarching process of quality assurance; including record-keeping, professional development, supervision and reflective practice. Relationships between each process are also noted and explored.

**Conclusions:** Current literature examining the role of a sport psychologist is both diffuse (across many different books/articles), disparate (i.e., not easily compared or reconciled) and inaccessible (i.e., language and concepts). Further, no existing model captures the complete process of a practicing sport psychologist from beginning to end. The model described in this paper attempts to address these concerns, and thus facilitate the training of new practitioners as well as an improved understanding of what sport psychologists do. The implications of these changes are critically evaluated; for example what might be the risks of creating an accessible language and transparent model for psychological practice? Overall, the paper concludes that it is possible to deliver world-class applied sport psychology to athletes of all ages/levels, not just the elite, and signposts the ways that this goal may be pursued.

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**Introduction:** Since 1971, the non-linear time constant, tau ( $\tau$ ), has been predominantly used within the literature for quantifying the kinetics of the increase in oxygen uptake (VO<sub>2</sub>) during exercise transitions to steady state. With this, the VO<sub>2</sub> response has been modeled using a mono-exponential function. From this function  $\tau$  is derived. Time to steady state is said to be approximately  $4\tau$ . However, during the past four decades there has been no objective comparison to the mono-exponential function. Furthermore, observation of the mono-exponential fit reveals poor agreement for the initial phase of the exercise transition. It is our hypothesis that the initial (after phase I to ~30 to 40s) response is linear and not mono-exponential.

**Methods:** Nine healthy male subjects of moderate to high level of self-reported cardiovascular fitness were asked to complete five steady state cycling bouts on a cycle ergometer from unloaded (0 W) cycling to 30, 45, 60, 75, and 90% of their ventilatory thresholds. Their VO<sub>2</sub> data was collected using indirect calorimetry. The total VO<sub>2</sub> data was processed using the conventional mono-exponential model as well as a new method for detecting time to steady state (TTSS). The onset kinetics data was then processed using a linear regression, and the standard error of the estimate (Sx.y) was compared to that of the mono-exponential fit for all cycling bouts. TTSS was compared to  $\tau$  and  $4\tau$ .

**Results:** There was a significantly lower Sx.y and a higher R for the linear vs. mono-exponential fit of the onset kinetic data. Two-way repeated measures analysis of variance showed that TTSS and  $4\tau$  were not different across 30, 45, 60, 75, and 90% VT intensities.

**Discussion:** The results indicate that there is far more complexity to the VO<sub>2</sub> response to steady state than previously thought. The onset kinetics is a linear response, while the subsequent data follows a non-linear curve to steady state. Interestingly, the slope from the linear regression of the onset kinetic data is similar across all subjects and absolute exercise intensity, independent of subject fitness and tau. This could indicate that there are no functional limitations between subjects during this onset phase, with limitations occurring for the latter transition to steady state phase. Finally, although TTSS and  $4\tau$  are shown to not be different, the continuing use of mono-exponential modelling could mask important underlying physiology of VO<sub>2</sub> responses to steady state.

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**Background:** In Judo, injuries are frequent and can be severe to the extent where athletes miss practice for long periods of time. Consequently, sport injury prevention for judo athletes is crucial. The aim of this study was to gather basic information that may assist in preventing sport injuries in judo, including physical fitness data collected from judo athletes when entering university as well as the rate and site of injuries during their collegiate careers.

**Methods:** The period of this study was ten years, and the subjects consisted of 373 male judo athletes at a Japanese University. When entering the university, athletes completed a series of physical tests, including body composition (body fat percentage was derived from height, body mass and 3-site skinfold assessment using the calculations from Nagamine et al. 1979), isometric knee extension strength (calculated relative to body mass), muscular flexibility (hamstring, quadriceps, around shoulder girdle using the finger vertebral distance, gastrocnemius), joint laxity (knee hyper-extension), and limb alignment (quadriceps-angle, varus and valgus knee alignment, foot pronation/supination). Throughout the athletes' collegiate careers, the number of injuries resulting in missing practice for a period of over one month was recorded and they were classified by site. Additionally, sport injuries with the highest numbers were divided into an injured group and a non-injured group, and their physical strength test data were compared for statistical difference.

There were a total of 53 sport injuries: knee joint injuries (56%), foot joint injuries (13%), shoulder joint injuries (11%), elbow joint injuries (9%), back injuries (5%), finger injuries (4%), and neck injuries (2%). The subjects with knee joint injuries ( $n=25$ ) had significantly weaker knee extension muscle strength in the injured leg ( $77.7\pm 22.2\%$  relative to body weight) when compared to the non-injured group ( $89.7\pm 22.2\%$ ,  $p<0.01$ ,  $n=348$ ). There were no significant differences between the 'knee-injured' and 'no injury' groups for any other physical testing results.

**Discussion:** These results indicate that it is important to pay close attention to mainly knee joint injuries among judo athletes, and that knee extension muscle strength is crucial for its prevention. In Judo, this factor may be particularly vital due to the high frequency of situations when athletes must carry their own and their opponent's weight. As more data is collected about foot, shoulder, elbow and back injuries, it may be possible to perform similar analyses to establish links between other physical fitness characteristics and injury incidence.

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### Effectiveness of a single Platelet Rich Plasma (PRP) injection to promote recovery in rugby players with ankle syndesmosis injury

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**Introduction:** To determine whether a single ultrasound-guided platelet rich plasma (PRP) injection into the anterior inferior tibiofibular ligament (AITFL) reduces the time for rugby athletes to return to function and match-play following MRI confirmed ankle syndesmosis injury.

**Methods:** Cohort controlled pilot study. Ten rugby union players were recruited during the 2014 season, and consented to receive a single autologous PRP injection into the AITFL within 14 days of MRI confirmed ankle syndesmosis injury. An historical control group included 11 rugby players between 2011 and 2013 who were treated conservatively with the same inclusion criteria and rehabilitation protocol as the intervention group. Participants followed a standardised rehabilitation protocol involving simple milestones for progression. Early functional tests were performed 2 weeks after the removal of the CAM-boot. Time to return to play was recorded. Repeat functional testing occurred within 1 week of return to play.

**Results:** Groups were comparable in anthropometrics and MRI injury severity. Time to return to play was significantly less in the intervention group ( $p=0.048$ ). Following return to play, athletes in the intervention group showed higher agility ( $p=0.002$ ) and vertical jump ( $p=0.001$ ). There was a lower level of fear avoidance associated with rugby in the intervention than the control group ( $p=0.014$ ).

**Discussion:** This study shows that following ankle syndesmosis injury, a single autologous PRP injection may reduce fear avoidance, improve functional capacity and accelerate safe and successful return to rugby.

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### Patterns of platelet rich plasma use among Australasian Sports Physicians

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**Background:** We hypothesised that the application, production and administration of platelet rich plasma (PRP) varies widely among Sports Physicians, bringing into question the validity and consistency of PRP described in research and clinical use. The current study allows an evaluation of current practice of Australasian Sports physicians with current evidence for the effectiveness of PRP.

**Methods:** We conducted an anonymous 23 question online survey of 153 current Fellows of the Australasian College of Sports Physicians (ACSP), using an emailed link. It was opened from April 2014 until August 2014.

**Results:** There was a 73% response rate, and 87% completion rate. The survey confirmed that although most Sports Physicians either provide PRP themselves or refer for it, there is wide variation in the application, production and administration of PRP. We found that only 37.5% of Sports Physicians perform platelet-rich plasma injections themselves. Forty nine percent of clinicians do not provide the service themselves, and only refer for PRP injections. The remaining 13.4% of clinicians do not inject PRP or refer for PRP injections at all. Clinicians who perform their own PRP injections vary from an average of 0 to 500 injections per month, with a median of 12 times per month. Forty percent of clinicians who perform PRP injections themselves use commercial kits (not exclusively), and 28.5% use activating techniques. For Sports Physicians who use or refer for PRP injections, tendinopathy was overwhelmingly cited ( $n=63$ ) as the condition for which clinicians thought PRP was most effective. Based on clinical experience, those clinicians thought PRP was effective for lateral epicondylalgia ( $n=30$ ), hamstring origin tendinopathy ( $n=17$ ) and patella tendinopathy ( $n=17$ ). Thirty respondents cited effectiveness for osteoarthritis, especially osteoarthritis of the knee. Australian Sports Physicians are far more likely to use PRP than their New Zealand counterparts ( $p=0.001$ ). Forty-five percent of Australian clinicians perform PRP injections compared with 6% of New Zealand clinicians.

**Discussion:** This study shows there is wide variability in the practices employed by Sports Physicians to produce and administer platelet rich plasma. There is a poor correlation between the best available evidence and the beliefs of Sports Physicians regarding clinical conditions responding best to PRP. There is a clear need for validation of clinic-based methods of producing platelet rich plasma. Future clinical research must consider real world practice and help develop guidelines that allow increased consistency between clinicians for this service.

### Association between fat percent and the basic physical capacities of children of 7-11 years at school stage of an educational institution in Bogotá – Colombia.

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**Introduction:** Obesity is a disease that progresses rapidly and generated chronic diseases both adults and children that are costly and difficult to treat. The decline of physical performance associated with obesity is an issue that has been addressed by several studies in which the alteration of aerobic capacity as the causal agent is disclosed, but is less addressed the decline in physical performance associated with other physical qualities. This work is developed as part of the academic field practice in education sector undergraduates' physical therapy from the National University of Colombia, the purpose of this study is to establish what is the degree of association between the percentage of fat and basic physical capacities (strength, flexibility and endurance) in children of second childhood.

**Methods:** Students of elementary school, between 7 to 11 years; who performed the FITNESSGRAM®. This is a correlational study to determine the strength of association between the percentage of fat and physical qualities as flexibility, strength and endurance.

**Results:** It was found significant association between fat percentage and PACER level ( $p = 0.0001$ ), push up ( $p < 0.0001$ ), abdominal strength ( $p = 0.0148$ ) and left shoulder flexibility ( $p = 0.03186$ ). It was not found association between vertical jump Sargent and fat percentage.

**Discussion:** The negative association between PACER level and fat percentage is significant, which is consistent with other studies that have shown that disproportionately increased weight at school age has an inversely proportional relationship with aerobic endurance. This weight gain is associated with sedentary lifestyles, which promotes obesity and increased energy expenditure and the need to mobilize more weight for oxidative activity that promotes faster reach the threshold that produces a higher glycolytic acidosis and speeds fatigue.

Fat percentage isn't related to vertical jump, although there are some studies in athletes (not children) that show that using an additional weight of body affects jump significantly, decreasing altitude and flight time, increasing -off time. Moreover If we consider children are in full swing and jump is one of the fundamental patterns whose maturation stimulates the development of certain motor skills, it's necessary to consider this result and the negative impact that a high percentage of fat can generate on motor development.

**Conclusion:** The fat percentage has high influence on physical performance in general, demonstrating once again the need to develop strategies to offset overweight, obesity and promote physical activity for minimizing the deleterious effects the health.

### Unhealthy Imbalance; Decreased Exercise and Poor Knowledge of Exercise as Medicine in Australian Medical Students the MEDx Study

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**Introduction:** Physical activity is important for medical student health and wellbeing. Furthermore, having the knowledge and skills to prescribe exercise for patients will help address the imminent burden of non-communicable diseases that these students will most certainly face. Evaluating these important areas is the goal of "MEDx", a study spanning 2 years exploring the perceptions and knowledge levels of postgraduate medical students towards exercise as medicine as well as investigating their physical activity levels. This is particularly pertinent as a growing body of evidence indicates that role-modeling and physicians' exercise habits greatly influence their exercise prescription. This study adds to the growing body of evidence supporting the inclusion of exercise prescription and physical activity in medical curricula.

**Methods:** An anonymous online quantitative and qualitative survey of Deakin University postgraduate medical students was undertaken regarding their exercise habits as well as their perceptions and beliefs surrounding exercise. Also assessed was students' knowledge of exercise as medicine. Subjects were recruited from the entire 4-year cohort biannually. Ethics approval was obtained from Deakin University Human research ethics.

**Results:** Response rates were consistently 1 in 4 (total  $n=436$ ) throughout the 2 years of this study. 32.45% (SD 10.4) of surveyed students met or exceeded current physical activity guidelines, despite the majority believing that practitioners exercise prescription is affected by exercise habits and that practitioner health influences patient health. Of concern is that 50.26% (SD 5.85) of participating students believe medical school hinders their exercise and indeed exercise levels dropped between preclinical and clinical years. Furthermore >85% of student participants believe exercise counselling is important for their future field and even more believe that good exercise habits of the doctors can encourage their patients to exercise. In relation to testing current knowledge including that of physical activity guidelines, across the surveys <0.5% of questions were correctly answered.

**Discussion:** There is a clear discrepancy between the views of medical students, their exercise-related actions and knowledge. Their knowledge seemed unchanged across the four years of this postgraduate medical course. Of concern was that there was an apparent decrease in students' exercise once entering the clinical environment, despite an increase in incidental exercise. It is clear that the academic environment is perceived as impairing physical activity levels of the students' and that they believe the university should proactively address this. Furthermore an apparent gap in the current curriculum pertaining to exercise as medicine and student understanding of current evidence based practice regarding this exists.

### Athletic performance and training characteristics in Junior Tennis Davis-Cup Players

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**Introduction:** In tennis, modern game has evolved from a primary technical sport to the current explosive sport becoming increasingly dynamic and faster based on strength, speed and power so that the physical performance of a player can be of great importance for competitive success. This evolution has led to an increased strain for players in both, training and competition. Therefore, the aim of the present investigation was to examine athletic performance and training characteristics of Junior Davis Cup-Players (DC) in comparison to their peers (U16-regional-squad players, RS), as well as to evaluate the impact of performance level on training characteristics.

**Methods:** Twelve nationally ranked male DC ( $15.6 \pm 1.1$  yrs,  $180.7 \pm 9.6$  cm,  $69.8 \pm 11.7$  kg) and 59 RS ( $15.2 \pm 0.6$  yrs,  $176.3 \pm 7.7$  cm,  $62.4 \pm 8.6$  kg) participated in the study. All subjects performed the standardized fitness test battery of the German Tennis Federation including strength, upper body power, speed, jumping ability and tennis specific endurance. A standardized interview was undertaken for data evaluation on training characteristics of a normal training week (out-of competition) including workload of tennis training (TT), physical training (PT), total training workload (TTW), ratio TT/PT and training history.

**Results:** Significant differences ( $p < 0.05$ ) were found in most of all physical performance test between DC and RS (hand grip: 55.2 vs 44.7 kg; back-extension: 40 vs 31 repetitions; countermovement jump: 40.7 vs 37.6 cm; serve velocity: 184.3 vs 171.2 km/h; medicine ball throw: forehand 1457 vs 1282 cm, backhand 1372 vs 1233 cm). Training characteristics differed significantly ( $p < 0.05$ ) between both groups. DC showed higher values in TTW (22.7 vs 14.4 h/wk), TT (15.1 vs 9.8 h/wk), PT (7.6 vs 4.5 h/wk); whereas no differences were found for ratio TT/PT and parameters of training history. In DC statistically significant relationship was found between TTW and tennis ranking ( $r = -0.78$ ,  $p < 0.01$ ).

**Discussion:** Results obtained indicate a higher physical performance level, especially in the upper body power and strength, as well as higher training workloads in DC. Although sport specific technical skills are predominant factors, we can suggest that the increasing highly competitive nature of youth tennis require notably high demands of physical fitness for competing on elite level. Given this distribution of limiting performance factors, it is of great importance to organize the fitness training as efficient as possible saving time for technical/tactical training, nevertheless high training volumes are indispensable for elite performance level.

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## Low Back Pain in German Elite Hockey Players

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**Introduction:** Back pain (BP) and especially low back pain (LBP) is a frequent health problem in the general population, in sports and also in field hockey resulting in enormous costs for the health care system. Detailed data on prevalence of LBP in German sportsmen and women is rare. From a biomechanical perspective movements in field hockey are characterized by forward flexion and rotation of the trunk. The forward flexed posture must be maintained during most of the duration of a game or training session causing high spinal loads. This might be related with the development of pain in the lower back. The study aimed to determine the prevalence of LBP in German elite field hockey players to clarify associations between hockey-specific posture and pain generation.

**Methods:** A self-reported standardized and validated questionnaire based on the Nordic questionnaire by Kuorinka et al. (1987) was sent to all members of the A-, B-, C- and D-squad of the national hockey team and the members of the State-of-Northrhine-Westfalia junior hockey team. The questionnaire includes several items on BP and LBP. Lifetime, 12-month, 3-month and point prevalence of LBP were determined. 107 field hockey players (47.8%) responded ( $m = 44$ ,  $f = 51$ ; mean  $\pm$  SD:  $19.3 \pm 4.5$  yrs.,  $174.1 \pm 9.2$  cm,  $66.3 \pm 10.3$  kg). X<sup>2</sup>-statistics were used to determine differences in LBP between gender, and the Pearson correlation coefficient was used for analyzing the effect of age.

**Results:** The reported lifetime prevalence of LBP in field hockey players was 72.3%. The 12-month, 3-month and point prevalence of LBP were 64.5%, 44.0% and 27.8%. Comparison of gender showed no significant differences. By analyzing the effect of the athletes age on prevalence of LBP, significant correlation were found for lifetime prevalence ( $r = 0.28$ ,  $p < 0.01$ ), 12-month ( $r = 0.24$ ,  $p < 0.05$ ) and 3-month prevalence ( $r = 0.28$ ,  $p < 0.05$ ).

**Discussion:** Results indicate a high prevalence of LBP in German field hockey players. Our results clearly revealed much higher prevalence of LBP compared to other studies. Murtaugh (2001) reported lifetime prevalence of LBP of 54% in field hockey players. Reilly et al. (1990) and Haydt et al. (2012) also found lower lifetime prevalence of LBP (53% and 56%). A possible reason for the higher prevalence in our study could be the high performance level and the associated high training loads. The results underline the necessity of specific prevention programs for LBP in elite field hockey players.

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## Low Back Pain in German Elite Rowers

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**Introduction:** Low back pain (LBP) is a frequent health problem in the general population resulting in enormous costs for the health care system. LBP also is one of the most frequently occurring complaints in sports. Detailed data on prevalence of LBP in German sportsmen and women is rare. Elite rowers are exposed to high strain on the musculoskeletal system and especially on the lower back due to their sport-specific loads during training and competition. Currently, there is no information on the prevalence of LBP in German elite rowers. This study aims at identifying lifetime prevalence and point prevalence of LBP in German elite rowers.

**Methods:** N=84 German elite rowers ( $m = 43$ ,  $f = 41$ ; age:  $20.7 \pm 3.4$  yrs., height:  $183.9 \pm 8.3$  cm, weight:  $77.3 \pm 11.5$  kg) of international and national competition level were asked to fill out an online questionnaire based on the validated "Nordic Questionnaire" (Kuorinka et al. (1987)). The questionnaire included several items on back pain and LBP. Further, it included questions on lifetime occurrence of LBP and on LBP during the last 7 days.

**Results:** Lifetime prevalence of LBP was 86.9% and point prevalence of LBP was 47.6%. There was no significant difference between LBP and sex or age.

**Discussion:** Our findings indicate that LBP is a relevant medical problem in German elite rowing. The pain in the lumbar spine seems to be omnipresent with a lifetime prevalence of nearly 90% and a point prevalence of nearly 50%. This prevalence data is much higher compared to findings in the literature. Bahr et al. (2004) described a lifetime prevalence of LBP of 63.3% and a point prevalence of 25.3% in elite rowers, and Fass et al. (2012) found a lifetime prevalence of LBP of 68% and a point prevalence of 19%. One possible reason for the very high prevalence values of LBP in the German elite rowers might be very high sports-specific and strength training loads. This has to be evaluated in further studies. The results underline the necessity of LBP prevention programs in addition to the discipline specific training loads.

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**Introduction:** More than 10 years ago the National Heart Foundation (NHF) of Australia introduced Heartmoves® exercise classes as a form of community cardiovascular disease (CVD) prevention and Phase III cardiac rehabilitation. The development of Heartmoves® classes was reportedly based on established evidence but these classes were not trialled and evaluated prior to implementation, and as yet have not been objectively evaluated. The purpose of this study was to investigate the composition and intensity of Heartmoves® styled classes, screening procedures, participant characteristics and instructor qualifications.

**Methods:** Facilities offering classes listed on the NHF website and within 20km of the University of Newcastle Callaghan Campus were invited to participate. Facility managers, class instructors and class participants completed specific questionnaires. Class participant questionnaires included questions on CVD history and risk factors, other medical history and medication use. Two investigators observed each class and recorded the presence or absence and time spent in warm up, cool down, aerobic conditioning, strength conditioning, and other activities. A maximum of 10 participants per class wore Polar Indoor Team-Sports heart rate monitors throughout their class and data were telemetered to an iPad for recording. Mean and highest heart rates during different class components and Borg ratings of perceived exertion (RPE) were recorded. Data were analysed using descriptive statistics.

**Results:** 82 class participants from 12 classes at 7 facilities (of 9 in area) participated. Classes had been offered at these facilities for a mean  $\pm$  SD of  $7 \pm 6$  y. All classes included the components of warm up, cool down, aerobic and strength conditioning; 58% of classes used a circuit approach to aerobic and strength conditioning. Participants exercised at low-moderate intensities based on heart rate (mean % maximum heart rate  $58 \pm 12\%$  for aerobic conditioning) and average overall RPE was  $6 \pm 2$  (out of 10). Mean age of class participants was  $70 \pm 8$  y, 27% ( $n = 24$ ) were referred by health professionals, 73% ( $n = 61$ ) attended for fitness, 61% ( $n = 50$ ) had CVD risk factors, but only 21% ( $n = 17$ ) reported diagnosed CVD.

**Discussion:** Community-based exercise classes listed on the NHF website and marketed to those with or at risk of cardiovascular disease appear to meet NHF guidelines for class components and intensity, but attendees are not usually referred by health professionals or have diagnosed CVD. Class intensity is sufficient for health benefits and within the range recommended for safety.

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**Background:** Evidence-based treatments for patellofemoral pain provide short to moderate term improvements, but a substantial proportion of patients still report persistent symptoms. One possible method for improving success rates over the long-term would be to use individual patient characteristics to match the right patient to the appropriate treatment. Midfoot width difference (MWD) of  $\geq 11$ mm from a weight bearing to a non-weight bearing foot posture has been identified as predictive of those who will have a successful outcome with foot orthoses to treat patellofemoral pain. This single case study presents a patient with a 10-year history of bilateral patellofemoral pain, and with  $\geq 11$ mm MWD, who was successfully treated with foot orthoses and foot muscle retaining.

**Methods:** A 23-year old female presented with bilateral peripatellar symptoms (Left > Right) and a worst pain score of 7/10 (numerical pain scale (NPS) 0=no pain, 10=worst pain imaginable). The number of pain free step-ups, step-downs and squats were 7, 2 & 6 (left) and 18, 3 & 6 (right) respectively. Left MWD was 12.1mm and the right was 11.2mm. Maximal voluntary isometric hip strength measurements were hip abduction (ABD) 71.1N(left) and 70.2N(right), adduction (ADD) 70.6N(left) and 61.1N(right) and external rotation (ER) 67.2N(left) and 64.7N(right). Based on  $\geq 11$ mm in MWD, the treatment plan consisted of foot orthoses combined with calf stretching and foot posture retraining. The primary outcome measure was global rating of change scale (GROC) on a seven-point Likert scale. The patient was reviewed 6 times over 7 weeks. At 3 weeks the foot orthoses were removed and the foot exercises progressed.

**Results:** At 16 weeks, the patient reported she was much better on the GROC and her pain was 0/10. Pain free step-up, step-downs and squats were 25, 25 & 25 (left) and 22, 25 & 25 (right) respectively. Hip strength measures were ABD 53.4N(left) and 57.5N(right), ADD 71.2N(left) and 74.1N(right) and ER 74.8N(left) and 78.7N(right).

**Discussion:** This case study demonstrates four key points for discussion. 1. MWD  $\geq 11$ mm at first assessment being associated with a successful response to foot treatments aimed. 2. Active neuromuscular control of the foot might compliment foot orthosis intervention and improve both short and longer-term outcome. 3. Foot orthoses are likely a temporary adjunct to enable pain control and more effective foot exercising 4. There were substantial differences in hip muscle strength profile with treatment only directed at the foot.

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**Introduction:** Previous research had consistently revealed that energy drinks had a positive effect on mental and psychomotor processes. Recently, energy drink companies have started to market a reduced sugar content version of energy drinks. As such the aim of this study was to assess the influence of a newly introduced reduced sugar energy drink on cognitive and perceptual motor performance.

**Methods:** The study was a randomised, double-blind, placebo-controlled, two-way crossover study comparing an energy drink and a placebo. Fifty working adults were recruited and attended three sessions in total. The first session was the pre-test whereby participants were subjected to a memory recall, concentration and reaction time tests. In the second and third sessions, participants were randomly assigned to consume either the

reduced sugar energy drink or the placebo, waited in a holding room for 45 minutes before being tested on the same measures as the pre-test. Repeated measures Anova were used to analyse the data.

**Results:** For memory recall and reaction time, there were significant differences between the test scores. No significant differences were detected in the tests scores for the concentration test.

**Discussion:** In line with previous research concerning energy drinks, the results showed that after the energy drink was consumed, participants had improvements in immediate recall and reaction time. This finding indicated that a reduced sugar energy drink too had a positive effect on mental and psychomotor processes.

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### Does self-regulatory exhaustion resemble muscular fatigue? Separating depletion/recovery from training/interference effects

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**Introduction:** Self-control is a tiresome task: whether resisting temptations, suppressing emotions, or tolerating discomfort. The analogy with muscular fatigue suggests that the “self-control” muscle gets depleted following exposure to self-regulatory workload and takes time to recover, which leads to performance degradation on subsequent self-control tasks, such as persisting through pain and discomfort. A common limited resource is typically assumed to underpin all self-regulation task performance: it can be depleted by any number of self-control tasks (from counting backwards to controlling one’s bladder) with subsequent performance declining on just about any other self-control task. However, recent cognitive and neuropsychological literature is converging on distinguishing several, empirically separable, and differentially depletable executive resource pools. Executive functions of shifting, updating and response inhibition have been shown to be differentially related to higher cognitive processing and to decline independently of one another. The current study examined the generality / specificity of executive performance decline following a socially sensitive judgment task (specifically targeting response inhibition capacity) but capturing this decline with both a response inhibition measure (the Stroop interference effect) and a task-switching performance measure (switching costs in the classic Donders task).

**Methods:** 83 athletes and 32 controls performed a task sequence that included a cued switching task and a connotative semantic categorisation of words with ambiguous social connotations from a sensitive topic (doping) to evoke impression management. The two self-regulatory tasks were counterbalanced and followed by an identical Stroop colour naming task. Depletion of the self-regulatory resource pool was assessed by the change in Stroop performance over baseline, controlling for impression management and cognitive flexibility.

**Results and Discussion:** The effects of self-regulatory load on both switching and inhibition performance did not resemble expected “resource depletion” effect. Instead, a consistent pattern of positive transfer was observed from a sustained executive task practice to the subsequent executive performance test that taps the same sub-domain of cognitive control. Decline only happened when the two measures were separated by a different task (i.e. in a ‘switching – inhibition – switching’ sequence). The generalized decline in executive performance typically observed in social cognition literature may, therefore, be a method artefact when response inhibition tasks are used to both induce and measure the executive decline. Results indicate that if the “muscle metaphor” is to maintain its explanatory power, it needs to account for both depletion/recovery and practice/interference effects in the dynamics of sustained cognitive performance.

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### Research on the Neurobiological Features of the Chinese Elite Woman Table Tennis Players

W. Zhou<sup>1\*</sup> • Z. Zhenmin<sup>1</sup> • X. Shang<sup>1</sup> • H. Chen<sup>1</sup>

<sup>1</sup>Chinese Institute of Sport Science

**Introduction:** The aim of this study was to explore the brain functional state and the brain neurotransmitters of the Chinese elite woman table tennis players.

**Methods:** By means of EEG and Encephalofluorograph (SET), 6 key players in the Chinese Woman Team were monitored in 2012 to 2014.

**Results and discussion:** (1) The brain arousal index level of a world champion, which reflected the state of brain excitability, was between 48% and 50%. The Index values of the 6 players in the 3 tests were more than 48%. The brain energy ratio of the world champion, reflecting the exercise the brain endured, was more than 1.95, and its critical value was 2. The ratio values of the 6 players were more than 1.95.

(2) Various neurotransmitters both played different physiological functions in the brain, and controlled a variety of activities to the body. For example, opioid peptides (OPI) associated with the transfer of excitatory, DA involved in the control of movement and emotional function, ACH concerned with excitability in all parts of the brain and directly involved in memory, 5-HT was inseparable to central fatigue and so on. The values of these neurotransmitters in the brain of the 6 players were in normal range.

(3) The evaluation to the brain state of the 6 player was that there were 3 “Good”, 2 “Best”, and 1 “Vigilance” in March, 2014 (before the world cup); and there were 4 “Good”, 1 “Best”, and 1 “Vigilance” in September, 2014 (before the Asia Games).

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### Exercising depression in young people: An exploration of symptom changes in response to exercise.

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**Background:** Major depressive disorder (MDD) is a highly prevalent and recurrent disorder with a complex aetiology. MDD embodies a diverse constellation of symptoms which influence mind, body, mood and behaviour. The clinical profile of MDD can vary substantially and some research suggests this may play a role in treatment course and response. MDD is typically treated with antidepressant medication and psychological therapy. More recent research suggests exercise may also have an antidepressant effect. However, very little research has investigated how depressive

symptoms change in response to exercise. This presentation describes patterns of depressive symptom changes in response to regular exercise among young people with MDD and reports preliminary change patterns across the phases of the intervention.

**Methods:** 12 participants with a mean age of 20.8 (1.70) satisfied DSM-IV criteria for MDD according to a structured diagnostic interview (SCID) assessed by a Clinical Psychologist. Participants also completed a number of self-report measures including the Beck Depression Inventory (BDI-II) to determine depression symptom severity at baseline, post intervention and at follow up. The BDI-II was also additionally administered at regular time points throughout the 12-week multi-modal group exercise program. The exercise intervention was offered 3 times per week for 1-hour duration. Participants were also encouraged to exercise for 30 minutes on all other days.

**Results:** Findings from the pilot study show a sizeable improvement in depressive symptoms at the end of the 12 week exercise intervention with a total BDI-II mean change score of 20.3 (10.6). At baseline participants reported an average BDI-II score of 32.0 (9.4) which falls into the severe range. Improvements in depressive symptoms were maintained at 9 month follow up with a mean change score of 21.6 (14.1). Three depressive symptom sub groups were also identified; cognitive, affective and somatic symptoms. Mean change scores reported by participants at 12 week follow-up were as follows: 8.9 (4.9) for cognitive, 6.6 (3.9) for affective and 4.8 (3.2) for somatic symptoms.

**Discussion:** The findings from this study suggest exercise may be beneficial in helping reduce depressive symptoms in young people with MDD. There is also some evidence that exercise may have differential effects on depressive symptom subgroups and further study is warranted. The findings of the pilot study have informed the development of a larger randomised controlled trial.

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### Exploring Upper Limb Joint Torques during Delivery in Elite Female Tenpin Bowlers

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Tenpin bowling looks to be inconspicuous in terms of injury incidence, but there has been documented evidence of common injuries at the wrist and thumb and anecdotal injury issues at the shoulder. There are also indications of possible high muscle forces that lead to higher bone mass density of the bowling arm. All these point to the possibility of reasonably high joint torques in bowling, and which has not been investigated before.

**Participants:** A total of six female elite Malaysian bowlers participated in this study (age 23.3±5.9 years, bowling average of 201.3±1.9 pin falls per game).

**Methods:** Upper limb anthropometric data was recorded for kinetic computations, while kinematic data was derived from 3D motion capture system at a bowling alley. Each bowler delivered four trials, which were time normalised from the top of back swing to ball release. A simple planar (2D) model was used. The mathematical model for a three-link kinematic chain of an arm was constructed based on Kane's vector-based approach method. Torques were reported as values normalised to the product of the participant's body weight and height.

**Results:** All bowlers displayed the highest torque values at the shoulder, followed by the elbow and wrist, which corresponds with proximal to distal segment contribution seen in throws. The shoulder displayed gradual increase of flexion torque slope from top of back swing right up to 70% of the delivery cycle, after which it exhibited a sharp decrease in flexion torque and corresponding increase in extension torques prior to ball release.

**Discussion:** The 'braking' component seen here could be an important factor in terms of motor correctional mechanisms as well as injury prevention whereby extension torques have been suggested to help increase compression forces on the shoulder complex during high velocity movements.

When compared to softball pitchers, these elite female bowlers exhibited higher peak shoulder flexion torque (8.1 %BW\*H) but lower peak extension torques (3.7 %BW\*H). It is possible that the higher flexion torques in bowling are due to the effort needed to move a significantly higher mass compared to softball. In summary, it is apparent that joint torques in bowling are quite pronounced. As it has been suggested that torques about the shoulder region of between 3-7 %BW\*H are sufficient to produce overuse injury, these elite female bowlers could therefore be constantly vulnerable to injury risks.

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### The Prevalence of Musculoskeletal Injury In Australian Paddle Sports

A R. Griffin<sup>1 2\*</sup> • D M. Perriman<sup>2</sup> • T M. Neeman<sup>2</sup> • P N. Smith<sup>1</sup>

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**Introduction:** Kayak racing has been an Olympic sport since 1936. The sport is evolving with the introduction of open ocean ski racing and alternative craft such as stand-up paddle boards (SUP). Musculoskeletal Injury incidence surveys have been conducted for ultra-marathon events but no data has been published for other racing formats.

**Objective:** To determine the prevalence of musculoskeletal injury amongst competitive Kayak, Ski, SUP and Canoe paddlers.

**Methods:** Competitors from six kayak or ocean surf ski races in Australia between October 2014 and April 2015 were surveyed. These races included the Australian Sprint Canoe Championships; The Doctor & 20 Beaches ocean races; Oceania Canoe Marathon Championships; The Hawkesbury Canoe Classic & Murray Marathon Ultra-Marathon kayak races. Prior to each race, competitors were asked to complete a voluntary questionnaire either online or in hard copy. The questionnaire investigated a number of factors including paddling related injuries over the past five years. Information about athlete morphology, equipment and its set up, training volume and training environment was also collected.

**Results:** 583 competitors in total were surveyed. Of these competitors the craft types used included 173 K1, 202 touring or sea kayak, 146 skis, , 42 Stand Up Paddle Board, 10 Outrigger Canoes and 10 Single Canoe (C1). Competitors in each discipline included 155 in Sprint, 90 marathon, 318 ultra-marathon and 208 ocean. The most frequent injuries overall were shoulder (31%), low back (23.5%), elbow and forearm (17.5%), wrist 16.5% and neck 13.7%. Prevalence of shoulder injury from highest to lowest was K1 paddlers (40.5%), ski paddlers (33.6%), SUP (28.6%) and touring and sea kayak (20.3%). Lumbar spine injury prevalence was highest in SUP (33.3%) and lowest in touring and sea kayak paddlers (18.3%). A significant association between low back and shoulder injuries was found overall (OR=2.2 [1.5-3.2]; p<0001). This association was largely driven by the touring and sea kayak paddlers. The average training distance per week was, highest to lowest, K1 (60km), ski (49km), SUP (33km) and touring or sea kayak (28km).

**Discussion:** The prevalence of shoulder injury in paddling sports is high, especially in K1 competitors who reported the highest training distance. No significant differences were detected between ski and K1 competitors in terms of injury profile. SUP paddlers appear to be more at risk of lumbar spine injury.

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## Evidence of long term durability on autologous tenocyte injection (ATI) for treatment of chronic lateral epicondylitis

Z. Ming Hao<sup>1\*</sup>

<sup>1</sup>University of Western Australia

**Purpose:** Chronic lateral epicondylitis is associated with degenerative tendon changes, extracellular matrix breakdown and tendon cell loss. To continue our previous 12 month pilot study on ATI for severe tendinopathy associated with chronic lateral epicondylitis (*Wang et al* AJSM 2013), herein we provide long-term follow up (36 months) data on ATI efficacy.

**Methods and Materials:** Patients with severe refractory lateral epicondylitis underwent clinical evaluation and MRI prior to intervention. A patellar tendon needle biopsy was performed and tendon cells expanded by in vitro culture in a GMP-certified TGA-licensed facility. As single injection of autologous tenocytes into the common extensor tendon origin tendinopathy under ultrasound guidance was performed. Patients underwent serial clinical evaluations (VAS pain, QuickDASH, grip strength and MRI) for up to 5 years post-injection. Repeat MRI scanning was performed at 1 year and at least 3 years post-injection.

**Results:** Twenty patients (11M:9F; mean age 49.4 years) were included in the study, with three patients withdrawing consent prior to ATI. Mean symptoms duration pre-recruitment was 31 months. Mean follow-up time was 4.5 years. No biopsy complications or any adverse events, infection or excessive fibroblastic reactions at the injection site were observed. One patient elected for surgery three months post-ATI after re-injury, and one died of natural causes during follow-up. In the remaining 15 patients, mean pain scores improved from 5.7 to 1.2 at final follow-up ( $p<0.001$ ). Mean QuickDASH score and grip strength scores also significantly improved over follow-up (84% and 207% increase, respectively;  $p<0.001$ ). MRI scoring of tendinopathy grade at the common extensor origin improved significantly at 12 months ( $p=<0.001$ ), and was maintained to final follow-up.

**Conclusion:** ATI significantly improved clinical function and MRI tendinopathy scores at 3-year follow up in patients with chronic lateral epicondylitis having previously undergone unsuccessful conservative treatment.

This study advocates the long term durability of ATI in treating tendinopathy.



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## FRIDAY 23 OCTOBER PAPERS AT A GLANCE

Time	Session	Title	Presenter	Room	Paper
0930-1030	Keynote	Effect of intensified training on muscle adaptations, performance and health	Jens Bangsbo	MacArthur's Ballroom	127
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		Running speed increases plantar load more than percent bodyweight on AlterG treadmill	Athol Thomson		129
		The case of barefoot running: Understanding its biomechanical implications; risk of injury and the individual response.	Nicholas Tam		130
		Training in a minimalist shoe improves running performance in trained distance runners	Jonathan Buckley		131
		Walking on inclined surfaces	Peter Milburn		132
		Examining the association between unilateral versus bilateral drop vertical jump landings and a sport-specific task	Natalie Saunders		133
		The effects of stability footwear on ACL-relevant knee biomechanics during landing in women	Kade Paterson		134
		Altered trunk movements during landing in people with anterior cruciate ligament reconstruction	Jodie McClelland		135
		Detecting biomechanical adaptations in sport-specific landing patterns using field-based ACL injury risk screening methods	Aaron Fox		136
1100-1230	Symposium	Physical literacy development in Australian youth: A current concern	Dick Telford	Leicester Room	137
		A Systematic Review of the Definitions, Foundations and Associations of Physical Literacy	Richard Keegan		138
		How should we measure movement competence in children?	James Rudd		139
		Inadequacy of physical education in our primary schools	Sarah Keegan		140
		Teaching fundamental skills: even PE specialists need to lift their game	Natalie Lander		141
		Improving physical activity levels in children: evidence for a gender specific approach	Rohan Telford		142
		Psychological consequences of physical literacy in primary school children	Lisa Olive		143
		Inadequate physical literacy and increased chronic disease risk in 12 year-olds	Dick Telford		144
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		Effects of Exhaustive Exercise on the ATP-sensitive potassium channel of Rat Cardiac Sinoatrial Node	Yun Chang		145
		Influence of active and passive recovery on physiological responses during rest period in interval swimming	Yoshimitsu Shimoyama		146
		The effect of sodium phosphate and beetroot juice on repeated sprint performance in female athletes	Karen Wallman		147
		Influence of sodium bicarbonate ingestion on variable duration repeated sprint performance in hypoxia and normoxia	Gary Brickley		148
		Do women experience the same ergogenic response to caffeine as men?	Tina Skinner		149
		Associations between functional threshold power, autonomic activation and immune function in aerobically trained cyclists	Subaru Yoshimoto		150
		Effects of contracting muscle mass on arterial and venous [K+] and muscular fatigue during intense intermittent cycling	Trevor Farr		151

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		Gait Kinematics and Kinetics in Individuals with Gluteal Tendinopathy	Kim Allison		154
		Isometric and Isokinetic Hip Strength in Symptomatic Femoroacetabular Impingement	Laura Diamond		155
		Efficacy of Prolotherapy Treatment for Sacroiliac Joint Instability and Pain	Bruce Mitchell		156
1330-1500	Invited: Joseph Hamill and Round Table: Have modern footwear reduced running-related injury risk?			MacArthur's Ballroom 1	157
1330-1500	Injury Prevention 1			Leicester Room	
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		No Reduction in Head Injurt Rates with Increased Helmet Use: The Case of Western Canadian Snowsports	Tracey Dickson		160
		Moderate evidence for the relationship between training or competition load and injury: A systematic review	Michael Drew		161
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		Eccentric knee-flexor strength and hamstring injury risk in rugby union: A prospective cohort study	Matthew Bourne		163
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1330-1500	Exercise Science 2			Romney Room	
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		Improving Muscular Fitness Enhances Psychological Well-being in Low-income Adolescent Boys: Findings from the ATLAS Cluster RCT	David Lubans		167
		Work-matched high-intensity interval and traditional continuous endurance training similarly attenuate maximal strength gain during concurrent training	Jackson Fyfe		168
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		Factors affecting performance outcomes for participants in home-based core strengthening programs	Angela Searle		170
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		Training and testing the top-class soccer player	Jens Bangsbo		174

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		A markerless motion capture technique for sport performance analysis and injury prevention: toward a 'big data', machine learning future	Jacqui Alderson		178
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		An evaluation of web- and print-based methods to attract people to a physical activity intervention	Stephanie Alley		182
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## 127 Effect of intensified training on muscle adaptations, performance and health

J. Bangsbo<sup>1\*</sup>

<sup>1</sup>The Department of Nutrition, Exercise and Sport, University of Copenhagen, Denmark

Performance in most sports is determined by the athlete's technical, tactical, physiological and psychological/social characteristics. The present keynote lecture will evaluate what limits performance in various sports, and how training can be conducted in order to improve performance. Specifically how intensified training, i.e. increasing the amount of aerobic high intensity and speed endurance training, affects physiological adaptations and performance of already trained subjects. Periods of speed endurance training does improve performance in events lasting 30 s – 4 min, and when combined with aerobic high-intensity sessions, also performance during longer events. Speed endurance training does lead to reduced energy expenditure and higher expression of muscle Na<sup>+</sup>,K<sup>+</sup> pump  $\alpha$  subunits, which may preserve muscle cell excitability and delay fatigue development during intense exercise. In addition, when conducted with the new method 10-20-30 training it does also improve health variables in recreational runners.

## 128 SYMPOSIUM: Revisiting the continuum of tendon pathology: understanding the relationship between pain, structure and function to target treatments

S. Docking • E. Rio • J. Cook

The continuum of tendon pathology was first published in 2009 in an attempt to synthesise basic science and clinical research into a model that assists the clinician in understanding the progression of tendon pathology, the critical factors limiting the tendon to return to function, and allowing for targeted interventions based on the stage of pathology. Since being published the continuum has been cited 110 times and has been adapted for the rotator cuff and equine tendon pathology. Six years later, it is worthwhile revisiting the continuum in the context of contemporary research and assess its relevance in the clinical setting.

A number of models of tendon pathology have been proposed prior to and subsequent to the continuum of tendon pathology. Critically, they differ in their proposed primary histological event that drives pathology (ie activation of resident tendon cells, infiltration of inflammatory cells or tearing of collagen fibres). These models will be discussed in regards to their similarities, strengths and weaknesses to the clinical condition.

A frequent criticism of the continuum is that the various stages are based solely on structural abnormalities in what is primarily a pain condition. While a direct relationship between structure and pain is not present, the role of tendon structure will be discussed in relation to pain. In revisiting the continuum, the role of pain, poor function and structure will be discussed during the symposium and suggesting that if you can't move up the continuum in terms of structure, maybe you have to go around it (just a little teaser!!!). This symposium will be applicable for the clinician with rehabilitation techniques and concepts discussed for lower and upper limb tendinopathy, as well as an open forum for discussion and questions.

## 129 Running speed increases plantar load more than percent bodyweight on AlterG treadmill

AWARD FINALIST

A. Thomson<sup>1,2\*</sup> • E. Einarsson<sup>1</sup> • E. Witvrouw<sup>1</sup> • R. Whiteley<sup>1</sup>

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**Introduction:** The concept of optimal loading to maximize healing and remodeling of injured tissues is considered a central tenet of modern sports medicine. A progressive graded return to weight-bearing is an important aspect of the management of many lower limb injuries. During over-ground and treadmill running, it is known that increasing running velocity increases the magnitude of plantar loads, however it is not known what the relation is when performing the same progressions in reduced gravity environments. The purpose of this study was to quantify the maximum plantar force across a range of clinically relevant speeds and indicated percentage bodyweights while on a reduced gravity treadmill.

**Methods:** 20 male amateur runners (Age 35.4 ± 7.8yrs) Weight (77.6 ± 8.4Kg) height (179.1 ± 5.6cm) completed 36 running trials in their preferred running footwear. Each trial was a combination of running speeds (from 6km/h to 16 km/h) and from 50% to 100% indicated percent bodyweight on an Alter-G treadmill (G-trainer pro 2.0, Alter-G, California USA). Plantar loading forces were measured using a Novel Pedar-X in-shoe system (Novel, Munich, Germany). The Maximum plantar force were normalized to each subjects bodyweight (BW) in order to facilitate comparison and were examined for the whole foot for each of the 36 running trials.

**Results:** Increasing gait speeds resulted in larger increments of maximum plantar force for the whole foot than increases of Alter-G indicated percent bodyweight for the ranges examined here. The relative differences in maximum plantar forces were seen to be greatest when increasing speed from 6 to 16 km/h while holding indicated percent bodyweight constant (range: 0.74BW to 0.91BW increase) whereas increasing indicated percent bodyweight from 50% to 100% showed a smaller increase in peak force (range 0.19BW to 0.31BW)

**Discussion:** Data presented may allow for an evidence informed graduated return to loading on a reduced gravity treadmill – clinicians can use the table to estimate peak plantar forces for different combinations of running speed (from 6 to 16km/h) and percent indicated bodyweight (from 50% to 100%). Increasing running speed (rather than increasing AlterG indicated percent bodyweight) was shown to have the strongest effect on increasing maximum plantar force across the ranges of speeds and indicated percent bodyweights examined.

## AWARD FINALIST

N. Tam<sup>1\*</sup> • J. Asteph Wilson<sup>2</sup> • R. Tucker<sup>3</sup><sup>1</sup>University of Cape Town • <sup>2</sup>Dalhousie University • <sup>3</sup>University of the Free State

**Background:** The popularity of barefoot running in recent history has emerged from scientific publications and translation from lay media about its potential benefits. Benefits include a decrease in injury risk (decreased initial loading rate) and increases in running performance. Alongside these purported benefits there is still a dearth in understanding whether all runners are able to adapt to the proposed benefits and how this may affect long-term injury risk.

**Methods:** Habitually shod runners (N=26; age=28.8, 21-41) agreed to participate in an 8-week purely barefoot running training study. The training program was designed to proportionally replace shod with barefoot running to prevent an additive training effect. Initial loading rate, sagittal ankle and knee joint angles and electromyography of the gastrocnemii, peroneus longus, tibialis anterior, rectus and biceps femoris and gluteus medius were collected at both pre- and post-intervention in the barefoot and shod condition. Individual responses to this program were analysed by grouping runners according to a change greater than 1 standard deviation (20 BW·s<sup>-1</sup> in loading rate pre- and post-training programme) of the initial barefoot loading rate group mean, resulting in non-; positive and negative responders.

**Results:** In general, no group changes were found over the training program with the persistence of condition differences in initial loading rate, knee and ankle flexion at initial ground contact. Changes in ankle flexion angle at ground contact were also found to be associated with changes in initial loading rate when barefoot (r=0.59; p=0.02) but not shod (r=0.10; p=0.62). Gluteus muscle activity during stance increased after training in both conditions. Increased pre-activation of peroneus longus and gluteus medius and decreased tibialis anterior were also associated with lower initial loading rates post-training. Individual response analysis found that positive responders increased ankle plantarflexion (N=7; +3.7°) and negative responders increased ankle dorsiflexion (N=6; +6.4°) at ground contact when barefoot. Positive responders increased gluteus medius and biceps femoris and decreased rectus femoris pre-activity when barefoot post-training.

**Discussion:** Not all runners adopt the purported biomechanical barefoot running characteristics over an 8-week pure barefoot running program. This finding also questions the generalizability of the favourable biomechanical responses of barefoot running as instinctive. The positive-responders to barefoot running were able to increase ankle plantarflexion at ground contact and increase posterior and decrease anterior muscle group pre-activation, as all contribute to a lower initial loading rate. The large individual responses to barefoot training should be further elucidated.

J. Fuller<sup>1</sup> • D. Thewlis<sup>1</sup> • M. Tsiros<sup>1</sup> • N. Brown<sup>2</sup> • J. Buckley<sup>1\*</sup><sup>1</sup>University of South Australia • <sup>2</sup>Australian Institute of Sport

**Introduction:** Transitioning to less cushioned (minimalist) running shoes may promote a forefoot strike and improve running performance through greater storage and recovery of elastic energy in the ankle plantarflexors. We hypothesized that a forefoot strike would increase plantarflexor loading during running training, promoting greater adaptation in these muscles and greater improvement in running performance.

**Methods:** Twenty-six trained distance runners (rearfoot strikers), who were unaccustomed to running in minimalist footwear, ran in minimalist and control shoes (order randomised). Energy absorbed and generated at the ankle joint was calculated from the integral of the ankle joint power-time curve during stance phase when running across a force platform. Stride frequency, stride length and ankle angle at initial foot contact were also calculated from kinematic data collected using a 12 camera VICON MX F20 system. An additional 50 rearfoot strike runners completed 6-weeks of prescribed running training while randomised to progressively transition to minimalist or control shoes. Running performance was assessed before and after training using a 5-km treadmill time-trial.

**Results:** Compared with the control shoe, running in the minimalist shoe resulted in more energy generation (66.8 ± 20.1 J vs 59.4 ± 14.8 J; P<0.05) but not energy absorption at the ankle joint (55.0 ± 24.1 J vs 49.4 ± 20.0 J; P>0.27). In the minimalist shoe, runners had increased stride frequency (87.0 ± 5.4 strides/min vs 85.5 ± 5.4 strides/min; P<0.05), decreased stride length (287.7 ± 17.8 cm vs 292.6 ± 18.4 cm; P<0.05) and a less dorsiflexed foot at initial foot contact (2.9 ± 8.9 ° vs 7.7 ± 6.3°; P<0.05). After 6-weeks of running training, runners in the minimalist shoes improved 5-km treadmill time-trial performance more than those in the control shoes (44.6 ± 38.3 s vs 24.5 ± 35.1 s; P<0.05).

**Discussion:** Running in minimalist shoes increased the energy generated by the ankle plantarflexor muscles with each stride and the number of strides taken per minute. This increased work may enhance training adaptations in the ankle plantarflexor muscles and contribute to the greater observed improvement in running performance. These findings suggest that training in a minimalist shoe for 6-weeks can improve running performance in trained distance runners.

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**Introduction:** During the loading phase of gait, the plantar surface changes its shape by as much as 3.4±1.3% in length and 6±2.1% in width, and arch height and arch index were reduced 23% and 20% respectively. However, details on the shape of the plantar surface during the loading phase of walking on inclined surfaces have not previously been reported.

**Purpose of the study:** This investigation applies a novel method of 3D plantar surface analysis to walking on a range of incline surfaces.

**Methods:** Eight subjects with differing foot arch characteristics were classified as low-arch, normal-arch, and high-arch. A midline and a number of cross sections were drawn on the plantar surface. Eight 30Hz video cameras were mounted underneath an AMTI glass-topped force plate

mounted flush with the elevated walking surface. The force plate surface was systematically raised 11° along different edges to represent medial/lateral and uphill/downhill inclined surfaces. Video frames were processed to produce a textured 3D surface of the sole. Cross section dimensions were derived showing the influence of ground support level on surface deformation. The ICC test results of four randomly selected subjects showed the ICC (2, 4) was 0.992 (0.979 – 0.999) with an overall accuracy of 0.11mm.

**Results:** The research found measurable differences in a foot plantar shape between gait on an uphill and downhill surfaces, as well as noticeable differences of the plantar surface shape between walking on medially and laterally inclined surfaces. For example, there is a medial shift of the contact area of the plantar surface, particularly the area at the heel during uphill walking. Another notable finding is that at midstance, the percentage change of cross-sectional area (CSA) at the forefoot during the downhill gait is generally larger than all other CSAs.

**Discussion and conclusion:** The objective was to present a novel technique to capture, create and analyse spatial data from a dynamic 3D model of the plantar surface of the foot. This can offer new insights into the geometric characteristic of the plantar surface, such as shape change (strain), morphology and orientation during gait on various inclined surfaces. This investigation raised a number of new ideas which could improve the understanding of plantar surface shape changes during the loading phase of gait on incline surfaces. Examples include the arthritic, obese and growing foot, and the possible aetiology of fascia tear for strenuous sports.

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### Examining the association between unilateral versus bilateral drop vertical jump landings and a sport-specific task

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**Background:** It has been suggested that the second landing of a drop vertical jump (DVJ) may better represent in-game mechanics associated with anterior cruciate ligament (ACL) injury risk. Due to the fact that noncontact ACL injuries occur most frequently during unilateral tasks, examining a DVJ where the second landing is performed on a single limb may be more indicative of lower limb biomechanics experienced during sport-specific manoeuvres. The purpose of this study was to compare lower limb biomechanics between the second landings of DVJs performed bilaterally versus unilaterally; and determine whether a unilateral DVJ is more representative of lower limb biomechanics during a sport-specific task.

**Methods:** Fourteen female netball players (24.3 ± 2.6 yr; 173.8 ± 8.1 cm; 68.7 ± 7.4 kg) performed three trials each of a standard bilateral DVJ (DL-DVJ) and a DVJ where the second landing was performed unilaterally (SL-DVJ). Participants also performed ten trials of a sport-specific landing task, that being a netball leap landing. Three-dimensional (3D) kinematics and kinetics from the second landings of the DL-DVJ and SL-DVJ were compared using one-dimensional statistical parametric mapping (SPM1D). SPM1D linear regression was used to examine the relationships between biomechanical variables from both DVJ tasks and 3D kinematics and kinetics from the leap landing.

**Results:** Compared to the DL-DVJ; the SL-DVJ resulted in reduced hip and knee flexion, greater peak frontal plane hip angles and frontal plane hip motion, and larger hip adduction and external rotation moments. Reduced knee flexion and greater knee internal rotation at initial contact of the DL-DVJ were predictive of reduced knee flexion and greater knee internal rotation during the leap landing, respectively. Peak hip adduction, knee abduction, knee internal rotation, knee abduction moments, and knee external rotation moments during the SL-DVJ were predictive of their corresponding peak values during the leap landing. Greater hip adduction at initial contact and peak knee adduction moment during the SL-DVJ were predictive of greater peak hip adduction and peak knee internal rotation during the leap landing, respectively.

**Discussion:** The differences in hip mechanics between the DL-DVJ and SL-DVJ suggested the latter placed a greater demand on proximal control of the lower limb during landing. In comparison to the DL-DVJ, a greater number of biomechanical variables from the SL-DVJ were predictive of lower limb biomechanical patterns during the sport-specific landing task, and thus may be a more applicable screening movement for ACL injury risk.

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### The effects of stability footwear on ACL-relevant knee biomechanics during landing in women

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**Introduction:** Female athletes are three to seven times more likely to experience an ACL injury than their male counterparts participating in the same sport. The majority of ACL injuries are non-contact and occur during landing and pivoting athletic tasks, suggesting intrinsic mechanisms under high loads are responsible. In particular, altered knee biomechanics such as increased knee joint moments (loading) and knee valgus ("knock knees") have been implicated. Although footwear has been shown to influence knee biomechanics in other populations, this has not been investigated in women performing tasks that stress the ACL. The aim of this research therefore was to investigate the effects of stability footwear on knee joint load and angle in women performing a single leg drop vertical jump (DVJ) task.

**Methods:** The knee biomechanics of 12 women (mean age 23.2, range 22-24) were assessed while performing a single leg DVJ in a stability shoe (ASICS Kayano) and barefoot, presented in random order. Box height was standardized to 30% of leg length. A 12 camera Vicon motion analysis system and two AMTI force plates were used to determine a measure of knee joint load (the knee abduction moment; KAbM) and knee valgus angle at contact, in addition to other lower extremity biomechanical variables. Mean differences (MD) between footwear conditions were assessed using dependent t tests, and effect sizes were estimated using Cohen's *d*.

**Results:** The motion control shoes significantly affected knee loading, with a 12% reduction in the KAbM (MD = -0.52Nm/kg, *p* = 0.04, *d* = 0.93) however there was no change in the knee valgus angle (MD = 0.10°, *p* = 0.84, *d* = 0.09). Other biomechanical changes were also observed with the stability shoe, including a 31% increase in the knee flexion moment (MD = 5.41Nm/kg, *p* < 0.01, *d* = 2.72) and a 9% decrease in the ankle dorsiflexion moment (MD = -2.11Nm/Kg, *p* < 0.01, *d* = 1.36).

**Discussion:** These results show that stability footwear improves knee biomechanics known to increase the risk of non-contact ACL injury in women. Given that footwear with stability features are widely available and relatively inexpensive, such shoes may provide a simple injury-prevention strategy at the population level. However, clinicians need to be aware that stability shoes change additional biomechanical variables, including some with the potential to increase the risk of other knee injuries common in this population.

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**Introduction:** Following anterior cruciate ligament reconstruction (ACLR) surgery, the biomechanics of the knee during single limb landing tasks are abnormal and may predispose this population to a higher risk of knee injury. It has been hypothesized that the position and control of the trunk during single limb landing tasks may be related to knee biomechanics and contribute to injury risk. However, little is known about the movements of the trunk in this population, and during landing movements in particular. Therefore, the aim of this study was to compare trunk movements between patients with ACLR and controls during a single limb landing and cutting task, and to investigate the relationship between trunk movement and knee joint biomechanics.

**Methods:** Thirty-one participants were included in this study – 18 had undergone ACLR surgery at least 18 months prior and had returned to playing their main sport; 13 were of similar age but without knee injury and served as a control group. Participants were asked to land on a single limb from a distance equal to their leg length and immediately spring at a 90 degree angle away from the stance limb. The lower limb and trunk kinematics were assessed during 6 repetitions on each limb using a 10 camera three dimensional motion analysis system. The primary outcomes were maximum angles of forward and lateral trunk inclination. An embedded force platform collected kinetic data, and allowed calculation of lower limb joint moments. All biomechanical characteristics were compared between groups and Pearson's correlation investigated the relationship between trunk movement and knee biomechanics.

**Results:** Participants with ACLR completed the task with lower knee flexion moment and knee adduction moment than controls ( $p \leq 0.05$ ). Participants with ACLR had greater excursion of forward trunk inclination than controls and less ipsilateral trunk lean ( $p \leq 0.05$ ). There was a moderate correlation that participants with greater forward trunk excursion also had lower knee flexion moment ( $r = 0.5$ ,  $p \leq 0.01$ ).

**Discussion:** This is the first study to describe trunk movements in an ACLR population. Despite having returned to sport, trunk movements were abnormal during this single limb cutting task in patients with ACLR. There was a moderate relationship between the trunk movements and lower limb biomechanics, which supports suggestions that control of the trunk contributes to the presence of abnormal knee biomechanics in this population. Rehabilitation to restore normal knee biomechanics and minimize risk of injury may be improved by including strategies to address trunk movements.

#### AWARD FINALIST

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**Background:** Field-based screening methods for anterior cruciate ligament (ACL) injury risk offer a simplistic way to identify dysfunction that may lead to injury or monitor adaptations to injury prevention programs. Currently, limited research exists linking changes in injury risk as determined by field-based screening methods to biomechanical adaptations during sporting manoeuvres. The purpose of this study was to examine the efficacy of two field-based ACL injury risk screening methods in detecting biomechanical changes after a six-week period during a sport-specific landing.

**Methods:** Fifteen female netball players ( $23.5 \pm 2.3$  yr;  $171.6 \pm 6.5$  cm;  $67.4 \pm 9.1$  kg) attended two testing sessions separated by a six-week period during which eight participants completed a neuromuscular training program, while seven continued their regular training. At both sessions; participants were screened using the Landing Error Scoring System (LESS) and Tuck Jump Assessment (TJA), and performed ten trials of a sport-specific landing task, a netball leap landing. Three-dimensional kinematics and kinetics of the lower limb were collected during landing trials. Pearson's correlation coefficients ( $r$ ) were used to measure the associations between changes in LESS/TJA scores and lower limb biomechanics over the six-week period.

**Results:** The average change in LESS and TJA scores were  $-0.4 \pm 1.5$  (range =  $-3 - +2$ ) and  $0.4 \pm 1.1$  (range =  $-1 - +3$ ), respectively. A decrease in LESS score was associated with reductions in hip adduction ( $r = 0.69$ ;  $p = 0.004$ ), reductions in initial contact ( $r = -0.64$ ;  $p = 0.009$ ) and peak ( $r = -0.53$ ;  $p = 0.040$ ) frontal plane knee angles, and increases in knee internal rotation ( $r = -0.68$ ;  $p = 0.005$ ) during landing over the six-week period. A decrease in TJA score was associated with increases in peak knee external rotation moments ( $r = -0.51$ ;  $p = 0.048$ ) during landing over the six-week period.

**Discussion:** A decrease in LESS score (i.e. decreased injury risk) was associated with kinematic changes proposed to reduce ACL injury risk. However, reduced scores were also associated with increases in knee internal rotation, signifying a more high-risk landing posture. Similarly, a decrease in TJA score (i.e. decreased injury risk) was only associated with increases in transverse plane knee moments, suggesting the TJA may be ineffective for monitoring biomechanical changes in the landing task examined. Neither method was able to efficaciously identify changes in lower limb kinetics, suggesting further screening may be required to monitor these risk factors.

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**Introduction:** The term "physical literacy" is now in common use, and refers to the individual's disposition towards physical pursuits (including physical activity) arising from the combination of motivation, self-confidence, movement capability, and appreciating the value of physical movement. Physical literacy is frequently linked to important health behaviours and outcomes. As such, promoting physical literacy is often presented as a way of

addressing growing health issues such as cardiovascular disease, diabetes and obesity. This symposium is a collaboration between researchers from four institutions, all investigating the role of physical literacy in Australian children.

In this symposium, Paper 1 (definitions) reviews the genesis of the term with a critical review of current definitions, assumptions, and proposed relationships. Motor skill is a core component of physical literacy, and so Paper 2 (measurement) describes how best to assess fundamental motor skill (FMS) and why current levels of FMS of young Australians are of concern. Paper 3 (typical current practices) throws some light on this concern in presenting evidence of current practice in public-funded primary schools, which demonstrates that current provisions failed to provide children with the prescribed quality and quantity of physical education. Paper 4 (current specialist provision) presents evidence that even specialist physical educators in secondary school may have difficulty in teaching FMS. The final three papers review the consequences of current physical literacy provisions in Australia. Low physical activity in Australian children is a proposed outcome of inadequate physical literacy, and Paper 5 provides evidence that boys and girls require different strategies to improve physical activity levels. Paper 6 addresses interactions between indices of physical literacy and psychological well-being. Finally, Paper 7 presents evidence of increased risk of chronic disease as a result of differences in PE provision and physical activity in 12 year-olds.

Paper 1: A systematic review of the definitions, foundations and associations of physical literacy

Paper 2: Fundamental motor skills: measurement issues and developmental concerns

Paper 3: Inadequacy of physical education in our primary schools

Paper 4: Teaching fundamental skills: even PE specialists may need to lift their game

Paper 5: Improving physical activity levels in children: evidence for a gender specific approach

Paper 6: Psychological consequences of inadequate physical literacy in primary school children

Paper 7: Inadequate physical literacy and increased chronic disease risk in 12 year-olds

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### SYMPOSIUM: Physical literacy development in Australian youth: A current concern.

#### Paper Title: A Systematic Review of the Definitions, Foundations and Associations of Physical Literacy

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**Introduction:** The concept of physical literacy has received increasing research attention in recent years, being applied to primary school PE, sport participation, and physical activity interventions. Research currently operationalizes the construct differently, depending on country, age-group and tradition/paradigm, leading to potential confusing over definitions and similarities/differences to related constructs. The aim of this systematic review was to collate, analyse and evaluate the core attributes of the physical literacy construct, as reflected in contemporary research literature.

**Methods:** In September 2014, five databases were searched with 35 published articles meeting the inclusion criteria. Peer-reviewed published papers that attempted to define and contextualise physical literacy were analysed in relation to: (i) definitions, (ii) philosophical foundations; and (iii) associations to other constructs (determinants and outcomes) – with a view to providing a definitive summary of the meaning and proposed importance of the concept. The criteria focused on peer reviewed, English publications that explicitly defined physical literacy in the full body of text. Data was extracted and analysed only if it pertained to the definition, core philosophy, or conceptual association of physical literacy. The methodology followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). The qualitative data extracted from the papers was analysed thematically.

**Results:** The thematic analysis identified both the core attributes that define physical literacy, as well as areas of conflict/tension between different approaches currently being adopted. In relation to philosophical underpinnings, one relatively clear approach emerged, but is also critiqued. This clear specification is contrasted against a number of papers that overlooked philosophical considerations. Finally, the analysis identified a number of factors that are believed to be associated with physical literacy, including physical and mental health, participation in physical activity, academic performance, and many more.

**Conclusion:** Inconsistent definitions and different philosophical positions currently undermine attempts to deploy, promote and investigate physical literacy. Clear areas of consensus and divergence are critically compared, and their consequences are explored, as interest in this topic grows. Recommendations, for both researchers and practitioners, focus on identifying and clearly articulating the definition being deployed, philosophy being adopted, and outcomes being sought.

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### SYMPOSIUM: Physical literacy development in Australian youth: A current concern.

#### Paper Title: How should we measure movement competence in children?

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**Background:** Over the past few decades decreased levels of movement competence in primary school children have been reported in Western countries, most notably here in Australia. Movement competence is an integral component of physical literacy, which has been defined as having the movement competence, knowledge, skills, and attitudes to live a healthy life and also to be an advocate for others to do the same. A limitation in the current definition of physical literacy is the ambiguity about what constitutes movement competence. At present, Britain, USA, and Australia assess movement competence largely by evaluating fundamental movement skills (FMS), whilst most European countries commonly assess general body coordination. Both of these assessment tools provide an overall movement competence score for a child, however it is currently unclear whether these assessments tools are measuring the same aspects of movement competence. The aim of this study was to 1.) investigate whether the Test of Gross Motor Development (TGMD-2) and Körperkoordinations Test für Kinder (KTK) measure the same aspects of children's movement competence; and, 2.) examine the factorial structure of the TGMD-2 and KTK in a sample of Australian children.

**Methods:** A total of 158 children participated (M age = 9.5; SD 2.2). Children were assessed on the TGMD-2 (six locomotor and six object control skills) and the KTK (four non-sport specific sub-tests measuring gross body coordination). First, confirmatory factor analysis (CFA) examined the

independent factorial structure of the KTK and TGMD-2 using AMOS 22 and, secondly, it was examined whether locomotor, object control, and body coordination loaded on the latent variable 'Movement Competency'.

**Results:** CFA indicated an adequate fit for both the KTK and TGMD-2. It also found that locomotor ( $r = .86$ ), object control ( $r = .71$ ) and body coordination ( $r = .52$ ) loaded on to the latent variable movement competence and that an adequate model fit was achieved.

**Discussion:** The TGMD-2 and KTK measure discrete aspects of movement competence. Future research should consider using a wider range of test batteries to assess movement competence in children. It follows that for children to be truly physically literate they should participate and be assessed in a wide range of activities.

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**SYMPOSIUM: Physical literacy development in Australian youth: A current concern.**  
**Paper Title: Inadequacy of physical education in our primary schools**

S. Keegan<sup>1\*</sup> • R. Keegan<sup>1</sup> • A. Herlt<sup>1</sup> • T. Lee<sup>1</sup> • L. Olive<sup>2</sup> • R. Telford<sup>1</sup> • R. Telford<sup>1</sup>

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**Introduction:** This paper investigates current practices in Australian Primary PE, using a naturalistic observation to establish lesson frequency, duration, PA-levels and pedagogy using SOFIT. The majority of PE lessons in primary schools are delivered by classroom teachers, and the benefits of using specialist teachers are reported to be lost if/when their services end. There is little data establishing the current day-to-day duration, frequency and content of primary-school PE lessons in Australia, because many existing data may not capture typical practice. The 2014 snapshot of primary school PE aimed to capture the practice of classroom primary teachers in delivering regular PE lessons – who are responsible for 80% of the target allocation of 150 min/week of PE. This study is unique in that it focuses on state primary schools, it did not rely on pre-arranged appointments to conduct observations, and it focused on the PE provision of classroom teachers.

**Method:** Naturalistic cross-sectional observation study using systematic direct observation of PE classes in Years 3-6 over a three-month period. By agreement with the school staff, 28 government run primary schools received a total of 91 random, unannounced 1-hour visits, from which 27 PE lessons were observed.

**Results:** On average, children received 13.5% of the mandated 150 minutes per week of PE, or 0.68 lessons per week, from the classroom teachers. PE lessons were an average of 30.4 minutes (SD = 11.3 min), of which 38.1% (mean = 11.02 min) was coded as moderate to vigorous physical activity (MVPA). 61.9 percent of time was spent being sedentary. Regarding teacher interactions, 46.9% of class time was spent observing, 34.7% giving instructions, and 14.7% managing behavior, with little or no 'promotion of fitness' or 'demonstration'. 32.0 percent of class activity was devoted to management, with 26.0% game-play, 22.5% skill practice, and 11.3% coded as fitness activity.

**Discussion:** On average, PE delivery by classroom teachers in state-run primary schools did not meet the mandated 150 minutes per week of PE, nor did it contribute meaningfully to the recommended 300 minutes per week of MVPA. The overall pattern of instruction could be described as "tell-and-do", focusing on instruction and observation/monitoring. High levels of instruction, management and queuing, as well as tasks that did not engage every child appeared to explain the low levels of MVPA observed. Possibilities for changing practices in primary PE are discussed.

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**SYMPOSIUM: Physical literacy development in Australian youth: A current concern.**  
**Paper Title: Teaching fundamental skills: even PE specialists need to lift their game**

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**Introduction:** A substantial proportion of young people have lower physical activity (PA) levels than desirable for good health, furthermore, physical activity declines throughout adolescence, particularly in females. Fundamental movement skill (FMS) competence is positively correlated with PA, but FMS proficiency is low, especially in girls. Physical Education (PE) provides an opportune environment to develop FMS. Effective teaching in PE has been considered the single most powerful influence on student achievement. One element of effective teaching could be viewed as successful motivation, both at the level of the teacher and the student. In the context of fundamental movement skills (FMS), low levels of proficiency, particularly among girls, suggest that teachers may not be creating a social context that adequately motivates students to improve their competence in these skills.

**Purpose:** The purpose of the present study was to explore teachers' perspectives and experiences when teaching FMS to early adolescent girls'. **Method:** Qualitative semi-structured interviews were carried out with 25 specialist Physical Education teachers to investigate perceptions of the importance of teaching FMSs, and the factors (barriers and facilitators) that impact on their teaching of FMSs. Inductive thematic analysis was performed to analyse the data.

**Results:** Two major themes emerged from the data: (i) teachers believed FMS instruction was important and timely for Year 7 girls, despite it not being core curriculum in high school; and (ii) teachers lacked competence in curriculum interpretation, pedagogical strategies, and meaningful assessment, which was perceived to inhibit teaching effectiveness.

**Discussion:** Teaching practice deficits may be due to the basic psychological needs of the teacher not being met, which in turn inhibited their teaching practice, and thus reduced the likelihood of meeting the students' psychological needs. Therefore, it seems practical that pre-service and in-service teacher education in FMS is proposed for improving teacher motivation and competence, and to emphasize the importance of teaching practices that promote the satisfaction of students' basic psychological needs, so that teachers can learn to structure FMS instruction in a motivationally adaptive manner.

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**Introduction:** A gender-based disparity in physical activity (PA) among youth, whereby boys are more physically active than girls is a persistent finding in the literature. Underlying mechanisms explaining this difference are not well established and few intervention strategies take a gender centric approach to increasing PA in primary school aged children. The purpose of the present study, using a socio-ecological framework and a longitudinal design was to determine whether influences on PA are the same for boys and girls and whether these influences are sustained over time.

**Methods:** 276 boys and 279 girls taking part in the Lifestyle of our Kids (LOOK) longitudinal study were assessed at age 8 and 12 years. PA was measured by pedometer, cardio-respiratory fitness (CRF) by the multistage run, percent body fat (%BF) by DEXA and eye-hand coordination (EHC) by a throw and catch test. Perceived competence and enjoyment in physical education, extracurricular sport participation and level of parent support for PA were assessed by questionnaire. Linear mixed-effects models, fitted separately for boys and girls, were used to analyse cross-sectional and longitudinal associations of variables of interest with PA.

**Results:** Boys were 20% more physically active than girls (12256 vs 9900 steps per day) at age 8-years and a similar magnitude of difference was observed at 12-years. Longitudinal evidence indicated that an increase in perceived competence in PE among girls but not boys was associated with an increase in PA from age 8- to 12-years. Higher CRF, higher EHC, lower %BF and participating in a sports club were associated with higher PA levels in both boys and girls at 8- and 12-years. However, the influence of sports club participation on PA diminished in girls by age 12 years. A notable gender difference emerged at 8-years, whereby higher levels of parent support and perceived competence and enjoyment in PE were associated with higher levels of PA among boys but not girls.

**Discussion:** We found evidence for gender-specific influences on PA participation and that these influences change at various stages of development. Of particular note for girls was the finding that increasing perceived competence in PE was associated with increases in PA, highlighting a useful target for PA interventions. Differences in the way parent support, sports participation and perceived competence in PE influence PA in boys and girls supports the premise that PA interventions should place greater focus on specific gender based strategies.

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**Introduction:** There are many benefits to children's overall development when they are physically active and literate. From a psychological perspective, it is believed that a physically literate child experiences better psychological wellbeing. The aim of the current study was to investigate how aspects of physical literacy (PL) affect the psychological wellbeing of children from the LOOK study. Specifically, we sort to determine whether attitudes of competence and enjoyment, perceptions of physical abilities, total physical activity and cardio-respiratory fitness (CRF) effect psychological wellbeing, including levels of stress, depression and body image.

**Methods:** Participants were 241 boys and 237 girls from the LOOK study. Psychological wellbeing was assessed using the Body Esteem Scale, the Children's Stress Questionnaire and the Children's Depression Inventory. Aspects of PL that were assessed included, Physical Education (PE) competence and PE enjoyment, assessed using the PE Attitudes for Kids (PEAK) Scale; Physical Abilities self-esteem, assessed using the Self-Description Questionnaire II (SDQ-II); the 20m multistage shuttle test (MSST) was used to assess CRF; and physical activity was assessed by pedometers. We investigated the effect of changes in physical literacy on changes in psychological wellbeing from grade 2 to grade 6 separately for boys and girls using general linear mixed modelling.

**Results:** Among girls, we found longitudinal evidence that increases in perceived enjoyment in PE are associated with improved psychological wellbeing, including reductions in depression ( $p=0.001$ ), stress ( $p=0.038$ ) and body dissatisfaction ( $p<0.001$ ), and further, that an increase in CRF is associated with reduced body dissatisfaction ( $p=0.17$ ). Among boys, we found longitudinal evidence that increases in self-esteem for physical abilities are associated with reductions in depression ( $p=0.038$ ), stress ( $p=0.016$ ) and body dissatisfaction ( $p<0.001$ ).

**Discussion:** Increasing PL in children can improve psychological wellbeing. Notable differences in the aspects of PL that effect psychological wellbeing were seen for boys and girls, whereby, perceiving PE as enjoyable had the greatest effect for girls, and perceiving one's self as being physically proficient had the greatest effect for boys. These findings are useful for informing PL program developers on how to engage boys and girls differently to improve psychological wellbeing. Encouragingly, improving psychological wellbeing is likely to influence further PL outcomes, such as increased physical activity and improved self-esteem and confidence with movement.

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**Introduction:** Primary school teachers are now under considerable pressure to improve NAPLAN rankings and together with increased curricula and administrative demands, reductions in the quality and quantity of physical education (PE) is becoming evident. Some Australian states employ more specialist PE teachers than others in primary schools but they are typically restricted to teaching just one class per week per child with little or no supplementary PE from classroom teachers. Considering that reduced physical activity and increased obesity are known causes of chronic disease in

adults we hypothesized that our current practice of PE in primary schools will lead to an increase in the incidence of early signs of risk of chronic disease as children enter secondary school.

**Methods:** As part of the Lifestyle of our Kids (LOOK) longitudinal study we measure our cohort of 830 children at ages 8, 10, and 12 years of age in grades 2, 4, and 6 in 29 schools in districts of similar average socioeconomic status to the Australian average. Thirteen of the schools received 90 minutes of specialized physical education per week conducted by qualified physical education teachers (the SPE group). The other 16 schools continued their usual or common practice of physical education incidence conducted by classroom teachers (the CP group). Measurements included height, weight, percent body fat (DEXA), fasting blood samples for blood lipids, insulin, glucose, and weekly physical activity (pedometers and accelerometers).

**Results:** With no group differences at baseline, the percentage of 12 year-old boys and girls with elevated low density lipoprotein cholesterol (American Heart Association published value of LDL-C, is 3.36mmol.L or 130 mg/dL) was higher in the CP group than in the SPE group (23% vs. 14%,  $p = 0.02$ ). Furthermore, and again with no differences at baseline, the percentage of children with HOMA-IR greater than 3, a suggested cut-off point for paediatric metabolic risk, was also higher in CP children than in SPE children (31% vs 22%,  $p = 0.03$ ). Exploration of relationships showed that increased risk was associated with an increase in adiposity and reduction in physical activity.

**Discussion:** Current educational practice in the ACT public primary school system, not atypical of public primary school systems around Australia, has many children entering secondary school at increased risk of developing chronic disease. Our data provide physical evidence of an Australian educational system at odds with the physical literacy needs of third millennium children.

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### Effects of Exhaustive Exercise on the ATP-sensitive potassium channel of Rat Cardiac Sinoatrial Node

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**Background:** Exercise-induced cardiac arrhythmia has been of great concern in the field of sports science and sports medicine. Athletes engaged in high-intensity training are at particularly high risk of atrial fibrillation. Recent studies indicate the involvement of ATP-sensitive potassium channel (KATP channel) involved in pathophysiology changes of arrhythmias, however, the underlying mechanisms are unclear. This paper discusses the subunit mRNA and current density of KATP channel of sinoatrial node at different time phrases after exhaustive exercise.

**Methods:** 180 healthy adult male SD rats were equally assigned into 9 groups, including 1 control groups, 4 groups undergoing single exhaustive swimming, and 4 groups undergoing 2-week repeated exhaustive swimming. Rats underwent swimming with loading (3% of body weight) on their tails. 2-hour exhaustive swimming was carried out for the repeated swimming groups 6 days per week for a total of 2 weeks. The samples were drawn from rats immediately, and at 4, 12, and 24 hours after exhaustive swimming. The mRNA expression of KATP channel subunit in SAN was analyzed by real-time fluorescent quantitative PCR. The current density of IK-ATP in SAN cells were analyzed by whole-cell patch clamp technology.

**Results:** The Kir6.2 mRNA expression of the repeated exhaustive swimming group were significantly higher than that of control group ( $<0.01$ ). The current density of IK-ATP of the repeated exhaustive swimming group were significantly higher than that of control group and single exhaustive swimming group ( $P < 0.01$ ).

**Summary:** Exhaustive exercise up-regulation the SAN Kir6.2 mRNA subunit expression, along with the corresponding current IK-ATP. The Exhaustive exercise induced remodeling of KATP channel may be one of an important mechanism of self-protection and exercise-induced SAN dysfunction.

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### Influence of active and passive recovery on physiological responses during rest period in interval swimming

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**Background:** The recovery conditions of rest period in interval swimming are classified into 2 major categories: active recovery and passive recovery. Although, several studies have shown about passive recovery condition of rest period in interval swimming, there were few studies on active recovery condition. Therefore, There is no consensus on the effect of active and passive recovery on physiological responses. Active recovery is used to accelerate recovery during rest period, aimed at increasing muscle blood flow, which in turn enhances the lactate removal, and possibly facilitates the rate of phosphocreatine resynthesis. The purpose of this study was to investigate the influence of active and passive recovery on physiological responses during rest period in interval swimming.

**Methods:** The present study involved well-trained college swimmers, and all experimental measurements were conducted using tethered leg kicking. The subjects performed a graded test and interval swimming tests within six consecutive days. The graded test was performed for measuring the peak oxygen uptake ( $VO_{2peak}$ ), the interval swimming tests were 6 rounds of swimming for 60 s, with 30 s of either active recovery or passive recovery. The tethered load of swimming period and active recovery period in interval swimming test were set at 100 % of  $VO_{2peak}$  and at 50 % of  $VO_{2peak}$ , respectively. Oxygen uptake was determined using a gas analysis system. Heart rate was recorded using short-range radio telemetry.

Muscle oxygenation were measured by oxyhemoglobin ( $O_2Hb$ ) and deoxyhemoglobin (HHb) levels at the left vastus lateralis muscle, which were determined using a near-infrared spectroscopy (NIRS) device. Blood lactate accumulations were measured at 1, 3, 5 min after each trial completion.

**Results:** Mean value for oxygen uptake during rest period was lower with passive recovery than active recovery. The heart rate responses during rest period were similar to oxygen uptake responses.  $O_2Hb$  variations during rest period for passive recovery were significantly higher than for active recovery. On the contrary, HHb variations during rest period for passive recovery were significantly lower than for active recovery. Blood lactate accumulations was not significantly different between active and passive recovery.

**Discussion:** These results suggested that there were different physiological responses at active and passive recovery conditions during rest period in interval swimming. It could be indicated that active recovery condition would be more effective compared to passive recovery for the improvement of aerobic endurance, because of higher oxygen uptake and heart rate response and lower muscular reoxygenation.

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**Introduction:** Ergogenic aids are often used by athletes in order to improve exercise performance. In this study, the effects of sodium phosphate (SP) and beetroot juice (BJ) supplementation were assessed on repeated-sprint ability (RSA).

**Methods:** Thirteen female team-sport participants completed four trials: (1) SP and BJ (SP+BJ), (2) SP and placebo (for BJ), (3) BJ and placebo (for SP) and (4) placebo (for SP+BJ), with ~21 days separating each trial. After each loading phase, participants performed a simulated team-game circuit (STGC) consisting of four 15 min quarters, with a 6 x 20-m repeated-sprint set performed at the start, half-time and end of the STGC.

**Results:** Total sprint times were between 0.95-1.30 s and 0.83-1.12 s faster for each RSA set and 3.25 s and 3.12 s faster overall (~5% improvement) after SP compared with placebo and BJ ( $p=0.02$ ,  $p=0.02$ , respectively; Cohen's effect size ( $d$ )=-0.51 to -0.90 for all sets).

Additionally, total sprint times were 0.48 s faster after SP+BJ compared with placebo (set 2;  $p=0.05$ , ~2% improvement). Furthermore, a main effect for trial ( $p<0.01$ ) determined that first sprint times were fastest after SP, with first sprints being 0.17-0.23 s and 0.15-0.22 s faster (~6% improvement) after SP compared with placebo and BJ, respectively for all sets ( $d=-0.50$  to -0.85). Best sprints were 0.13-0.23 s and 0.15-0.20 s faster (~6% improvement;  $p<0.01$ ) after SP compared with placebo and BJ, respectively for all sets ( $d=-0.54$  to -0.89).

**Discussion:** SP improved RSA in team-sport female athletes when fresh (set 1) and fatiguing (sets 2 and 3). Specifically, total, first and best sprints were faster after SP compared with placebo and BJ.

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**Introduction:** Previous studies suggest that oral ingestion of sodium bicarbonate ( $\text{NaHCO}_3$ ) prior to repeated sprints activity can enhance performance. Many of these studies used a fixed duration of exercise, which may not maximally stress all energy pathways. Few studies are based on repeated sprints in normoxia conditions not hypoxia. Aim: The purpose of this study was to determine if  $\text{NaHCO}_3$  supplementation would enhance variable duration repeated sprint cycling in normoxia and hypoxia.

**Methods:** Ten moderately trained and healthy students (eight male, two female;  $21 \pm 1$  years,  $177.9 \pm 6.8$  cm,  $73.0 \pm 12.0$  kg) were tested in this double-blind, randomised, placebo controlled study on SRM ergometers. Ninety minutes prior to exercising they either consumed 500ml of fluid containing  $300 \text{ mg} \cdot \text{kg} \cdot \text{bm}^{-1}$  of sodium bicarbonate, 500 ml of fluid placebo or no supplementation. Fingertip blood samples were taken before, during and after the protocol. The sprint protocol consisted of a 6, 30 and 180-second sprint of isokinetic cycling, at  $90 \text{ rev} \cdot \text{min}^{-1}$  on an SRM ergometer with 3 and 5 min rest periods between efforts. Subjects exercise in normoxia and hypoxia ( $14\% \text{ O}_2$ ) in both conditions.

**Results:** Pre-exercise bicarbonate concentration and pH values were significantly higher in the  $\text{NaHCO}_3$  trial ( $p < 0.05$ ) compared to baseline and placebo. In normoxia no improved performance (peak power, mean power, end power) could be observed for all sprints. In hypoxia, there was a significant difference found between the pre-supplementation and sodium bicarbonate in the 30 second sprint ( $F_{2,6} = 10.18$ ;  $P = 0.033$ ).

**Discussion:** In conclusion, this study found that sodium bicarbonate has a positive effect on peak power output in repeated sprint performance in hypoxic conditions. Modifying training sessions in hypoxia with sodium bicarbonate may enhance performance in repeated sprint efforts with a high glycolytic demand.

#### AWARD FINALIST

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**Introduction:** Ingestion of 3-6 mg/kg body mass of caffeine significantly improves endurance performance in men. However, results of similar investigations in women are variable, likely due to the paucity of data available. Although several factors influence caffeine metabolism, including sex hormones, research to-date is yet to directly compare the ergogenic potential of caffeine in women and men using the same exercise protocol. This study aimed to 1) determine if consumption of caffeine improves endurance cycling performance in women and 2) determine if sex differences exist in the magnitude of the ergogenic and plasma responses to caffeine. It was hypothesised that women would experience significant performance improvements following caffeine ingestion, but that this ergogenic effect would be less than that observed in men, despite similar plasma caffeine concentrations between sexes.

**Methods:** Twenty-seven endurance-trained cyclists and triathletes, comprising 11 women (age  $29.7 \pm 5.3$  years, body mass  $59.5 \pm 9.7$  kg, maximal oxygen uptake  $51.9 \pm 7.2$  mL/kg/min, mean  $\pm$  SD) and 16 men (age  $32.6 \pm 8.3$  years, body mass  $78.5 \pm 6.0$  kg, maximal oxygen uptake  $60.4 \pm 4.1$  mL/kg/min, mean  $\pm$  SD) participated in this randomised, double-blind, placebo-controlled, crossover study. Participants completed an incremental exercise test to exhaustion, two familiarisation trials and two performance trials. Ninety minutes prior to the performance trials participants ingested opaque capsules containing either 3 mg/kg body mass of anhydrous caffeine or a placebo. The performance trials required participants to complete a set amount of work equivalent to 75% of peak sustainable power output for 60 minutes on an electromagnetically-braked cycle ergometer. Plasma was sampled at baseline, pre- and post-exercise for caffeine. Strict standardisation and verification of diet, hydration, training volume and intensity, and for women, contraceptive hormone phase was implemented.

**Results:** Performance was significantly improved following caffeine administration in women (placebo: 4036±440s, caffeine: 3865±328s;  $p=0.03$ ) and men (placebo: 3903±341s, caffeine: 3734±287;  $p<0.001$ ). The magnitude of performance improvement was similar for women and men (4%). Plasma caffeine concentrations were similar between sexes pre-exercise, but significantly greater in women post-exercise ( $p<0.001$ ).

**Discussion:** Ingestion of 3 mg/kg body mass of caffeine enhanced endurance exercise performance in women. The magnitude of the performance enhancement observed in women was similar to that observed in men, despite significantly greater plasma caffeine concentrations following exercise in women. These results suggest the current recommendations for caffeine intake (i.e. consumption of 3-6 mg/kg caffeine prior to exercise to enhance endurance performance), which are derived almost exclusively from studies on men, may also be applicable to women.

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## Associations between functional threshold power, autonomic activation and immune function in aerobically trained cyclists

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**Background:** According to Allen and Coggan (2010), the functional threshold power (FTP) has been defined as the highest average power output that can be sustained for approximately one hour, depending upon athletes' trained status, which is one of the important key factors to be successful for cyclists. While there are many important factors for cyclists, the physiological associations between functional threshold power, autonomic activation and immune function still remain to be elucidated. The purpose of this study was to clarify the relationship between FTP, salivary  $\alpha$ -amylase and IgA levels in moderately trained cyclists.

**Methods:** Ten aerobically trained male cyclists (age: 19.7±1.3 year; height: 171.2±6.7 cm; body weight: 64.3±13.0 kg; body mass index: 21.9±3.2 kg/m<sup>2</sup>; body fat: 15.3±2.6 %; peak oxygen uptake (VO<sub>2peak</sub>): 67.6±9.0 mL/kg/min, mean±SD) participated in this study. The VO<sub>2peak</sub> test was carried out, followed by the FTP tests, on two different occasions. To determine the FTP values, a 20-min time trial test was adopted (an average power from 20-min an all-out effort) as one of the most practical and accessible methods. Unstimulated salivary samples were taken at the 10-min period before (Pre) and after (Post) a 20-min time trial exercise for the later analysis of salivary  $\alpha$ -amylase and IgA levels which were quantified by an enzymatic assay and turbidimetric immunoassay, respectively.

**Results:** A relation between FTP and VO<sub>2peak</sub> was significantly correlated ( $p<0.05$ ). In contrast, there were no significant correlations between FTP, salivary  $\alpha$ -amylase and IgA levels.

**Discussion:** Previous research has demonstrated FTP as a key determinant of endurance athletic performance. However, there was a paucity of data available with respect to associations between functional threshold power, autonomic activation and immune function in aerobically trained cyclists. The results of the present study suggest that FTP values appear to be in association with aerobic fitness (training adaptation) regardless of acute responses of salivary  $\alpha$ -amylase and IgA levels.

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## Effects of contracting muscle mass on arterial and venous [K<sup>+</sup>] and muscular fatigue during intense intermittent cycling

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**Introduction:** Potassium regulation is vital in muscle membrane excitability, which has been linked to fatigue. However, the effects of contracting muscle mass on K<sup>+</sup>-dynamics, excitability and fatigue have not been thoroughly investigated. We therefore investigated the effects of two- (2L) and one-legged (1L) cycling on arterial and venous plasma [K<sup>+</sup>], muscular force, excitability and exercise performance.

**Methods:** Eleven recreationally-active adults (10 males, 1 female) (mean±SD) performed separate 2L and 1L graded cycle ergometer tests, to determine V<sub>O<sub>2peak</sub></sub>. On separate days participants then performed 2L and 1L trials, comprising cycling 6x2min at 80%V<sub>O<sub>2peak</sub></sub> with 90s recovery; then at 90%V<sub>O<sub>2peak</sub></sub> to fatigue. Quadriceps maximal isometric voluntary contraction (MVC) and potentiated twitch (P<sub>t</sub>) and v.medialis and v.lateralis M-wave (amplitude, duration integral, latency) evoked via magnetic stimulation were measured before and post-exercise. Radial arterial (a) and antecubital venous (v) plasma [K<sup>+</sup>] were measured at rest, during and post-exercise.

**Results:** [K<sup>+</sup>]<sub>a</sub> increased throughout exercise, being 35% and 26% greater at fatigue than rest for 2L and 1L, respectively ( $P<0.05$ , time main effect), but did not differ between trials. Plasma [K<sup>+</sup>]<sub>v</sub> increased at fatigue for 2L and 1L (5.98±0.64 and 5.34±0.43 mmol.l<sup>-1</sup>, respectively,  $P<0.05$ ), with no difference between trials. The [K<sup>+</sup>]<sub>a-v</sub> difference was greater in 2L than 1L ( $\Delta$  0.96±1.5 vs. 0.22±0.23 mmol.l<sup>-1</sup> respectively,  $P=0.02$ ). Cycle time to fatigue did not differ between trials. The MVC decreased from rest to fatigue by 17% for 2L (135±59 vs 112±57 Nm, respectively) and 26% for 1L (144±57 vs 107±63 Nm, respectively) ( $P<0.05$ ) with no difference between trials. The P<sub>t</sub> decreased at fatigue in both trials (14.5±8.5 vs. 10±8 Nm) but did not differ between trials ( $P=0.057$ ). The M-wave latency and duration did not differ between trials or times. The M-wave integral for v.medialis differed between trials ( $P=0.01$ ), decreasing by 24% at fatigue in 2L (18±11 vs. 14±12, respectively) but not for 1L (18±12 vs. 17±11); but did not differ for v.lateralis. The M-wave amplitude did not differ between trials; but decreased from rest to fatigue ( $P<0.05$ ) for v.medialis in 2L (3.4±2.8 vs 1.9±2.1 mV, respectively) and 1L (3.4±2.8 vs 2.3±2.0 mV, respectively) and v.lateralis for 2L (3.4±2.4 vs 2.0±1.6 mV, respectively) and 1L (2.4±2.3 vs 1.7±1.7 mV, respectively).

**Discussion:** Hence exercise with a large contracting muscle mass did not augment the increase in systemic [K<sup>+</sup>], and had similar relative declines in peak and twitch torque compared to exercise with the smaller muscle mass. The M-wave amplitude decreased with fatigue giving some evidence of excitability changes but this did not differ between trials with different muscle mass. Thus plasma [K<sup>+</sup>] is precisely regulated during intense exercise regardless of contracting muscle mass, probably via activation of muscle Na<sup>+</sup>,K<sup>+</sup>-ATPase.

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Recurrent exposure of ballet dancers' hips to extreme ranges of motion is believed to lead to hip osteoarthritis (OA). However, there is insufficient evidence to support this. Hip OA is thought to involve multiple articular structures such as the articular cartilage and acetabular labrum. A causal link between labral tear, ligamentum teres (LT) tear and early onset of hip OA has been suggested. With advances in imaging and arthroscopic techniques there has been an increased awareness and diagnosis of these intra-articular injuries. Despite a dramatic rise in the rate of hip surgery, over the past 10 years The Australian Ballet's medical team have successfully managed hip pain and pathology conservatively. Their philosophy of prudent evaluation of imaging findings and thorough rehabilitation is the key to their success and lead to a hypothesis that ballet dancers are at no greater risk of hip OA compared to other athletes and not all intra-articular pathology is symptomatic. A study was conducted to compare the prevalence of intra-articular pathology in professional ballet dancers with age and sex-matched sporting participants and to evaluate the relationship to clinical findings. 3T magnetic resonance imaging revealed a high prevalence of intra-articular pathology in hips. Labral tear, cartilage defects and LT tears were the 3 most common pathologies identified, their prevalence increased with aging and they co-existed in the majority of hips. There was a high prevalence of acetabular labral tear and cartilage defects and the frequency did not differ between professional ballet dancers and athletes. There was a higher prevalence of LT tear in professional ballet dancers compared to the sporting population and complete and partial tears of LT were not related to trauma or serious injury. Importantly, articular cartilage defects, labral tear and LT tear were not associated with hip pain. These findings highlight the need for caution when interpreting MRI as not all intra-articular pathology identified with imaging is clinically relevant. This presentation will discuss the findings of this study and the directions of future research.

AWARD FINALIST

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**Background:** The use of isometric exercises in the initial stages of tendon rehabilitation is common, however, effectiveness of hip isometric exercises in eliciting maximal gluteal muscle activity is yet to be quantified. The aim of this study was to compare the muscle activity of tensor fascia latae muscle (TFL), gluteus medius and gluteus minimus muscle segments during three isometric hip rehabilitation exercises in symptomatic women with greater trochanteric pain syndrome (GTPS) with matched asymptomatic women.

**Methods:** Intramuscular electrodes recorded electromyographic muscle activity from the anterior (GMinAnt) and posterior (GMinPost) portions of the gluteus minimus and the anterior (GMedAnt), middle (GMedMid) and posterior (GMedPost) portions of gluteus medius muscles in 18 post-menopausal women: ten asymptomatic (mean = 59.61 years) with no history of hip pain, injury or surgery, and eight symptomatic with a clinical diagnosis of greater trochanteric pain syndrome and a score of <80 on the VISA-G questionnaire. A surface electrode was used to gather data from TFL. Participants completed three sustained (15s) isometric hip exercises: hip hitch, hip hitch with contralateral toe tap and hip hitch with contralateral hip swing and three repetitions of three submaximal voluntary isometric contractions (SMVIC): hip abduction +/- external rotation and internal rotation against gravity for eight seconds in side lying. Average amplitudes were established and a Mann-Whitney U test was used to identify differences in muscle activity between the groups.

**Results:** A trend towards greater GMinAnt, GMinPost, GMedAnt, GMedPost muscle activity across all three exercises was found in the symptomatic group compared to the asymptomatic, with only significant findings for GMinPost during the hip hitch exercise ( $p=0.042$ ) when normalised to %SMVIC. Conversely, greater activity in GMedMid and TFL was found in the asymptomatic group, with significant findings for GMedMid during hip hitch with contralateral toe tap ( $p=0.006$ ), and for TFL during both the hip hitch and hip hitch ( $p=0.015$ ) with contralateral hip swing ( $p=0.004$ ).

**Discussion:** Greater segmental muscle activity (GMinAnt, GMinPost, GMedAnt, GMedPost) in the symptomatic group may indicate increased neural drive as a compensatory strategy for hip abductor strength deficits, and loss of their lateral stability mechanism. Reduced TFL activity in the symptomatic group may indicate preferential use of other surrounding musculature to provide stability to the hip joint (rectus femoris, vastus lateralis), or, illustrate a need for targeted rehabilitation of this muscle.

AWARD FINALIST

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**Background:** Gluteal Tendinopathy (GT) is a prevalent cause of lateral hip pain most frequently affecting women aged 40-60 years. Individuals with GT commonly report lateral hip pain during walking which can lead to a reduction in activity levels and subsequent detrimental effect on health and well-being. It is postulated that abnormal biomechanics during gait are associated with the presentation of GT; however there has been little such research to date. The aim of this study was to compare three-dimensional gait kinematics and kinetics between those with GT and healthy controls.

**Methods:** Three-dimensional gait analysis was conducted on 40 individuals with unilateral GT and 40 controls. Kinematic and kinetic data were calculated from the ground reaction force and marker clusters using inverse dynamics, and hip moments normalized to body weight times height. Values for the first peak, mid stance, and second peak external hip adduction moment during stance were compared between the two groups using an analysis of covariance, with walking speed as a covariate. Hip, pelvis and trunk frontal plane angles were similarly compared at these three hip

adduction moment time points. Linear regression was performed to investigate the relationship between kinematics and the magnitude of the hip adduction moments in those with GT.

**Results:** The GT and control groups were comparable in age ( $54.2 \pm 8.7$  vs  $54.4 \pm 9.3$  years) and number of males ( $n=9$ ) and females ( $n=31$ ). The GT group had a greater mean BMI ( $26.3 \pm 4.2$  vs  $24.0 \pm 2.6$  kg/m<sup>2</sup>,  $p<0.05$ ). Those in the GT group demonstrated greater first peak ( $p = 0.009$ ), mid stance ( $p<0.001$ ) and second peak ( $p<0.001$ ) external hip adduction moments than controls. The GT group exhibited greater contralateral trunk lean ( $p = 0.04$ ) at the first peak hip adduction moment and greater pelvic obliquity ( $p=0.04$ ) at the second peak hip adduction moment. A significant positive relationship was found between pelvic obliquity and the first ( $R= 0.354$ ,  $p=0.03$ ) and second peak hip adduction moment ( $R= 0.573$ ,  $p<0.001$ ) and between hip adduction and second peak hip adduction moment ( $R=0.362$ ,  $p=0.02$ ) in those with GT.

**Discussion:** To our knowledge, this is the first study to investigate three-dimensional gait biomechanics in those with GT. Individuals with GT exhibit greater hip adduction moments throughout stance, partially explained by greater pelvic obliquity and hip adduction angles. Findings provide a basis to consider frontal plane trunk and pelvic control in the treatment plan for management of GT.

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## Isometric and Isokinetic Hip Strength in Symptomatic Femoroacetabular Impingement

### AWARD FINALIST

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**Introduction:** Femoroacetabular impingement (FAI) is a morphological hip disorder that can cause hip/groin pain and impaired performance in younger active adults, plus lead to stiffness, muscle weakness, structural damage, and possibly hip osteoarthritis. There is limited evidence regarding hip muscle weakness in people with symptomatic FAI, and no study has examined isokinetic hip rotation strength in this population. Understanding the underlying hip muscle function associated with FAI is crucial to guide treatment and rehabilitation strategies. The study objective was to compare isometric and isokinetic hip strength between people with and without symptomatic FAI.

**Methods:** Fifteen people with symptomatic FAI diagnosed by clinical examination and with imaging features, and 14 age-, gender-, BMI-, and activity level-matched asymptomatic controls (with no evidence of morphological FAI on MRI) underwent strength testing. Maximal voluntary isometric contraction (MVC) strength of all hip muscle groups was measured with a Lafayette hand-held dynamometer; strength of dynamic hip internal rotation (IR) and external rotation (ER) was measured with a Kincom isokinetic dynamometer (angular velocity of 20°/s). Strength was recorded as torque and normalized to body mass (Nm/kg). Angle at peak torque and ROM were recorded. Between-group comparisons were made using t-tests for independent samples and Mann-Whitney U tests where required ( $p<0.05$ ).

**Results:** The FAI and control groups were comparable for age ( $25 \pm 5$  vs.  $27 \pm 5$ , respectively), BMI ( $24.4 \pm 2.5$  vs.  $23.2 \pm 1.9$ ), gender (males: 73% vs. 71%), and leg tested (dominant: 67% vs. 64%). Abduction strength was 30% lower in the participants with FAI than controls ( $p=0.04$ ). There were no significant differences in isometric MVC strength for other muscle groups. The ratio of isometric, but not isokinetic, IR/ER strength was significantly lower in the FAI group ( $p=0.03$ ). There were no differences in peak isokinetic strength in IR or ER; but IR ( $p=0.01$ ) and ER ( $p=0.03$ ) ROM were significantly less in FAI participants.

**Discussion:** Individuals with symptomatic FAI demonstrate hip muscle weakness and imbalance relative to those without the condition. Reduced abduction strength may compromise femur and pelvis position, and thus allow the hip to move into the impinging position during single leg weight bearing tasks. These findings provide a foundation to consider that assessment and training of muscle strength may be required in clinical management of FAI patients. Future research is required to investigate whether strengthening programs can lead to clinical benefits in FAI.

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## Efficacy of Prolotherapy Treatment for Sacroiliac Joint Instability and Pain

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**Background:** Prolotherapy is a non-surgical treatment for chronic musculoskeletal pain in damaged ligaments or tendons. It involves injecting a soluble solution, such as dextrose, into affected sites to induce a localized inflammatory response that stimulates the growth of collagen fibres and connective tissue. A previous study of 25 patients with sacroiliac joint (SIJ) pain and instability reported a functional improvement in 76% following prolotherapy. Here, we assess the efficacy of prolotherapy in treating diagnostically-confirmed SIJ instability and pain.

**Methods:** This is a prospective, observational study, conducted at a private, tertiary pain practice, performed over three years, assessing 131 consecutive patients undergoing prolotherapy treatment around the SIJ. The deep interosseous ligament was outlined with contrast material under direct fluoroscopy followed by injection with 1.5ml Naropin 0.75% and 10ml 50% glucose over multiple sites. Injections were repeated, on average three times, at 6-weekly intervals and follow-up assessments were conducted at 6 and 12 months post-treatment using clinical histories and patients self-reported responses to validated questionnaires. Outcome measures included back/hip/pelvic strength, pain relief, Oswestry Disability Index (ODI) score, patient satisfaction and analgesic use.

**Results:** At study end, two-thirds of patients reported improvements in pelvic/lumbar strength. Mean strengthening was 59.4% and 71.1% of patients achieved at least 50% improvement. Two-thirds of patients also experienced at least some pain relief (mean 51.6% reduction) at 12 months, while 80% reported they had 50% or better improved stability. Clinically meaningful mean ODI score reductions (of 6.58 points at 6mths and 8.27 points at 12mths) were observed across the study course. Almost half the cohort reduced their use of analgesia post-treatment and 70% of patients were satisfied with the outcomes from the prolotherapy procedure. Pain relief was dependent on improved strength ( $r^2=0.77$ ,  $p<0.001$ ) and correlated with reductions in disability score ( $r=-0.467$ ,  $p<0.001$  at 6mth).

**Discussion:** Prolotherapy, when applied in carefully selected patients, can be an effective treatment for increasing stability and strength, decreasing pain and reducing disability in a significant proportion of patients with SIJ pain and connective tissue laxity.

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Running related injuries have been reported in studies by several groups (McKean 2006, Taunton 2003, Clement 1981, Macintyre 1991) since 1980. Generally, these results can be interpreted such that there has been no change in the incidence (~30-46%/year) or the location of the injuries (majority of injuries to the knee; ~40-47%/year). Many researchers have interpreted this to mean that the advances in athletic footwear have not been sufficient to provide runners with relief from injuries. However, running-related injuries are multi-factorial and while running footwear is a single risk factor, it is not the only risk factor. While there have been many advances/design features in running footwear over the years to increase shock absorption, to control medio-lateral function, to increase the traction of footwear, to increase the breathability of the upper, etc., it has been difficult to relate these advances to the reduction of running-related injuries. The problem with many of the research studies that have investigated this question have been retrospective in nature and thus do not completely answer whether modern footwear reduces running-related injuries. There have been relatively few prospective studies that have investigated this question. As a result, we cannot completely answer whether modern footwear can reduce running-related injuries. One major development in footwear over the years that has been suggested is that footwear is task specific. That is, different footwear constructions should be employed for different types of running. While we may never answer the question in the title definitively, we do know that modern running footwear are probably 'safer' than the shoes used several decades ago.

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**Introduction:** Data from sports injury surveillance systems are the primary requisite for the development and evaluation of injury prevention strategies. This review aimed to identify sports injury surveillance systems currently in operation internationally, and thereby determine the sports and settings for which knowledge gaps still exist. A secondary aim was to determine which of the reviewed sports injury surveillance systems have evaluated the quality of their data and to report the results of those evaluations. By reviewing studies of sports injury data quality, there is potential to identify possible sources of error or gaps in surveillance data and to clarify whether particular surveillance methodologies could be improved.

**Methods:** A systematic search of peer-reviewed and grey literature was carried out to identify: i) publications presenting details of sports injury surveillance systems within clubs and organisations; and ii) publications describing the quality of data from these systems. Data extracted included methodological details of the surveillance systems, methods used to evaluate data quality, and results of these evaluations.

**Results:** Following literature search and review, a total of 14 sports injury surveillance systems were identified. Eleven of the 14 surveillance systems were found to exist within professional and elite sports, and only three within non-professional sports. Six of the included systems operate within various football codes and six collect data on male athletes only. No surveillance systems were found that are devoted solely to female athletes, nor are there any aimed specifically at recording injuries in children. Publications concerning data quality were identified for only seven (50%) systems. Validation of system data through comparison with alternate sources has been undertaken for only four systems (29%).

**Discussion:** Sports injury surveillance systems with high quality data are needed to monitor sports injury trends and to design and evaluate sports injury prevention strategies. This review identified that the majority of sports injury surveillance systems currently exist only within professional and elite sport settings, exacerbating the knowledge gap about injuries in amateur and community sport settings. Also, across all current sports injury surveillance systems, further validation studies are required. Although this is a difficult and time-consuming process, without these quality assessment studies there will continue to be limited scope to reduce error in surveillance data and improve surveillance practices.

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**Background:** The FIFA Medical and Research Centre (F-MARC) have designed a comprehensive warm-up program targeting muscular strength, body kinaesthetic awareness, and neuromuscular control during static and dynamic movements to decrease injury risk for soccer players. Prior studies have investigated the effectiveness of the F-MARC programs but have not consistently reported a benefit from the programs. The purpose of this study was to conduct a systematic review and meta-analysis of randomized controlled trials and interventional studies that evaluated the efficacy of the F-MARC injury prevention programs in soccer.

**Methods:** Two independent researchers performed a search on the Cochrane Central Register of Controlled Trials via OvidSP, AMED: Allied and Complementary Medicine via OvidSP (1985 – present), Embase, PubMed, MEDLINE, SPORTDiscus, Web of Science, CINAHL and AusSportMed. The keyword domains used during the search were F-MARC, FIFA 11+, the11+, injury prevention programs, soccer, and variations of these keywords. The initial search resulted in 4299 articles which were filtered to 9 articles that met the inclusion criteria. Main inclusion criteria were RCT or interventional studies, use of F-MARC injury prevention programs, and primary outcome measuring overall and lower extremity injuries. Extracted data were entered and analysed using Comprehensive Meta-Analysis software, Version 2 (CMA.V2).

**Results:** The pooled results based on total injuries per 1000 hours of exposure showed that the F-MARC injury prevention programs had a statistically significant reduction in the overall injury risk ratio to 0.771 (95% CI: 0.647-0.918,  $p = 0.003$ ) and lower extremity injury risk ratio of 0.762 (95% CI: 0.621 – 0.935,  $p = 0.009$ ). Moreover, F-MARC '11+' had a statistically significant reduction in the overall injury risk ratio of 0.654 (95% CI: 0.537- 0.798,  $p < 0.001$ ) and lower extremity injury risk ratio of 0.612 (95% CI: 0.475- 0.788,  $p < 0.001$ ). However, F-MARC '11' did not

reach significance for overall and lower extremity injury reduction. It can be suggested that teams involved in F-MARC '11 +' warm up program will reduce injury rates between 30% and 50% in the long term compared to the teams that do not engage in the F-MARC programs.

**Discussion:** This systematic review and meta-analysis indicated that use of the F-MARC injury prevention programs, particularly the '11+' program, decreases the risk of injuries among soccer players. These data also support the case for the development and introduction of sport specific programs.

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## No Reduction in Head Injurt Rates with Increased Helmet Use: The Case of Western Canadian Snowsports

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**Introduction:** There is increasing concern about the long-term effects of sports-related head injuries, such as concussion, with a growing focus on prevention (Koh 2011, McCrory, Meeuwisse et al. 2013). For snowsports, helmets are recommended as an effective strategy for reducing head injuries, including concussion (Hagel, Pless et al. 2005, Cusimano and Kwok 2010, Haider, Saleem et al. 2012). This research explores the association between helmet use and the rates and types of reported head injuries in alpine skiing and snowboarding at lift-accessed snowsport resorts.

**Methods:** Analysis of 88,193 injuries reported to, and diagnosed by, Western Canadian ski patrol departments from 2008-09 to 2012-13. Descriptive statistics, chi-squared and odds ratios were used to explore relationships and between-group differences. Contributing factors were explored via binary logistic regression.

**Results:** Head injuries are relatively rare (0.2 per 1,000 skier visits). The proportion of all reported snowsport injuries that are head injuries did not decrease over the study period despite increased helmet usage. Odds ratios indicated that a higher proportion of cases that reported a head injury were wearing a helmet than for injury types other than to the head. There was a significant difference in the type of reported head injury, with helmet wearers reporting proportionately less head lacerations. Odds ratios indicated that alpine skiers were more likely to report a head injury when wearing a helmet than snowboarders ( $p < .001$  cf.  $p = .22$ ). There were significant differences in the attributes of helmet wearers vs. non-helmet wearers, with the latter more likely to be: young adults ( $p < .001$ ), beginner/novices ( $p = .004$ ), or snowboarders ( $p < .001$ ). Helmet wearing was not associated with gender ( $p = .191$ ).

**Conclusion:** Over the study period, head injuries remain a relatively rare event. However, in contrast to previous suggestions that snowsport helmets could reduce head injuries by 15-60% (Ackery, Hagel et al. 2007, Cusimano and Kwok 2010), increasing helmet usage from 2008-09 to 2012-13 in Western Canadian resorts have not resulted in a decrease in reported head injuries.

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## Moderate evidence for the relationship between training or competition load and injury: A systematic review

AWARD FINALIST

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**Introduction** Training load has long been associated with injury risk. Currently, there are no systematic reviews to qualify this statement however.

**Methods:** The PRISMA guidelines were followed. An a priori search strategy was applied to four databases: Medline, SPORTDiscus, CINAHL and Embase. Studies were included if they analysed the relationship between training or competition loads and injury. The exclusion criteria were: the participants were not monitored longitudinally; case studies, case series or surveys; articles did not report any measures of load or injury; the relationship between load and injury was not analysed; review articles or animal studies. The quality of the studies included in the review was evaluated using the Newcastle Ottawa Scale (NOS) for assessing the quality of non-randomised studies in meta-analyses. The level of evidence was defined by the van Tulder et al (2003) criteria.

**Results:** 732 studies were identified with nineteen studies meeting the inclusion criteria. Studies evaluated the relationship between injuries and training load in sub-elite and professional rugby league players ( $n=6$ ) followed by cricket ( $n=4$ ), Australian football ( $n=2$ ), water polo ( $n=1$ ), rugby union ( $n=1$ ), rowing ( $n=1$ ), basketball ( $n=1$ ), baseball ( $n=1$ ), middle distance runners ( $n=1$ ) and various sports combined ( $n=1$ ). Moderate evidence for a significant relationship was observed between training loads and injury incidence in the majority of studies ( $n=16$ , 84.2%). The mean NOS score was 6.0 (range 5-8).

**Discussion:** The training load applied to an athlete appears to be related to their risk of injury, but there is some conflicting evidence for the relationship to illness. Sports science and medicine professionals working with athletes should monitor this load and avoid acute spikes in loads. It is recommended that internal load as the product of rate of perceived exertion (10-point modified Borg) and time be used when determining injury risk in team based sports. External loads measured as throw counts should also be managed and collected across a season to determine injury risk in throwing populations. Injury monitoring should occur for at least four weeks after spikes in loads. Future research should include randomised controlled trials to increase the level of evidence from moderate to strong by the van Tulder et al (2003) criteria however; the authors acknowledge the difficulties of achieving this in elite sport.

## Neuromuscular upper limb training significantly reduces major shoulder injury rate in elite Rugby League Players.

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**Background:** Major shoulder injuries are common in elite level rugby league players. Upper limb neuromuscular training is evidenced as a preventative intervention in several sports; however no evidence has been reported in the rugby codes which have a unique injury profile. This study retrospectively assessed the effect of a specific shoulder neuromuscular training program on the occurrences of major shoulder injuries in an elite level rugby league club.

**Materials and methods:** A retrospective review of major shoulder injury rates was conducted at an elite level rugby league club over a six year period between 2007 and 2012. A specific preventative neuromuscular shoulder exercise program was introduced during the 2010 season. An age-adjusted comparison between the 2007 – 2009 seasons (pre-neuromuscular training period) and 2010 – 2012 seasons (neuromuscular training period) was conducted.

**Results:** Overall, the observed major shoulder injury rates dropped significantly ( $p=0.011$ ; exact binomial test) by more than 50% after the introduction of the neuromuscular training program (from 15.8%/anno to 7.7%/anno). Age was generally inversely associated with injury risk and the achieved preventative effect size of training. Younger athletes aged less than 20 years were highest risk and profited most with an observed reduction by more than 80%.

**Discussion:** Collision sports have a high rate of shoulder injuries which presents a unique and under studied population. Lower limb prevention strategies are well established and proven effective. This shoulder program has adapted many of the established lower limb prevention strategies for the upper limb and shoulder. The results mirrored lower limb data with high prevention effect in younger, higher risk athletes and poorer results in older athletes. This neuromuscular training program should be considered for shoulder injury prevention in collision and combat sports with high injury rates. Further randomised prospective studies are needed in the future to validate these findings.

## Eccentric knee-flexor strength and hamstring injury risk in rugby union: A prospective cohort study

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**Introduction:** Hamstring strain injuries (HSIs) represent the most common cause of lost playing time in professional rugby union. Lower levels of eccentric knee-flexor strength and between-limb imbalances in eccentric knee-flexor strength have been associated with an increased risk of HSI in other sports; however these variables have not been explored in rugby union. This study aimed to determine if lower levels of eccentric knee-flexor strength or greater between-limb imbalance in eccentric knee-flexor strength during the Nordic hamstring exercise, are risk-factors for HSI in rugby union players.

**Methods:** This prospective cohort study was conducted over the 2014 Super Rugby and Queensland Rugby Union seasons. In total, 178 rugby union players (age,  $22.6 \pm 3.8$  years; height,  $185 \pm 6.8$  cm; mass,  $96.5 \pm 13.1$  kg) had their eccentric knee-flexor strength assessed using a custom-made device during the pre-season. Reports of previous hamstring, quadriceps, groin, calf and anterior cruciate ligament injury were also obtained for all players. The main outcome measure was prospective occurrence of HSI in the ensuing competitive season.

**Results:** Twenty players suffered at least one HSI during the study period. Players with a history of HSI had a 4.1 fold ( $RR = 4.1$ , 95% CI = 1.9 to 8.9,  $p = 0.001$ ) greater risk of subsequent HSI than players without such history. Between-limb imbalance in eccentric knee-flexor strength of  $\geq 15\%$  increased the risk of HSI 2.4 fold ( $RR = 2.4$ , 95% CI = 1.1 to 5.5,  $p = 0.033$ ) while an imbalance  $\geq 20\%$  increased risk 3.4 fold ( $RR = 3.4$ , 95% CI = 1.5 to 7.6,  $p = 0.003$ ). Lower levels of absolute eccentric knee flexor strength and other prior injuries were not associated with an increased risk of future HSI. Multivariate logistic regression revealed a significant relationship between previous HSI and between-limb imbalance, whereby the risk of re-injury was augmented in players with strength imbalances ( $p < 0.001$ ).

**Discussion:** Previous HSI and between-limb imbalance in eccentric knee-flexor strength were both associated with an increased risk of HSI in rugby union players. These results support the rationale for reducing imbalance, particularly in those players who have suffered an HSI, to mitigate the risk of future injury.

## High Intensity Running Increases Risk of Hamstring Strain Injury in Elite Australian Rules Footballers

### AWARD FINALIST

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**Introduction:** Hamstring strain injuries (HSIs) are a problematic issue across all sports requiring high intensity running (HIR). Reports show that within the Australian Football League (AFL) HSIs have remained the most frequent and prevalent across the last two decades. Numerous studies have investigated risk factors associated with this injury, however, to date there have been no studies that have specifically targeted how HIR exposure can effect injury risk. Therefore, the aim of this study was to explore whether a relationship exists between accumulated weekly HIR and HSI.

**Methods:** This retrospective study recruited fifty, elite, male footballers (mean age = 22.2 years, range = 18-30 years, height =  $188.2 \pm 7.1$  cm, weight =  $86.6 \pm 8.7$  kg and years playing AFL =  $3.7 \pm 3.1$  y) from a team in the AFL. Internal loads (session rating of perceived exertion x session duration) and external (running) loads (HIR ( $m \geq 24$  km/hr), distance (km), acceleration ( $m > 3$  m/s/s) and deceleration ( $m < -3$  m/s/s)) were collected daily over the 2013 and 2014 AFL seasons. For each individual, the two-year mean and standard deviation were determined for all variables. Z-scores were calculated using the formula:  $Z = (WM - 2YWM)/2YSD$ , where WM is the weekly mean, and 2YWM and 2YSD are the two year

weekly mean and standard deviation, respectively, across both seasons. For each injury, the sum of HIR z-scores for weeks 1-4 leading up to injury were recorded for the injured player and those teammates with complete datasets for that time period. Each data point was grouped into either injured or uninjured, to assess the association of HIR z-scores for weeks 1-4 leading up to injury and HSI odds ratios were used.

**Results:** Across the two seasons participants covered, on average, a total distance of  $806.6 \pm 95.2$  km and  $775.3 \pm 166.2$  km of which  $22.56 \pm 8.31$  km and  $15.45 \pm 5.45$  km made up of HIR, respectively. There were a total of 22 HSIs across the 2013 ( $n=11$ ) and 2014 ( $n=11$ ) seasons. Z-score sums were calculated for the four weeks leading up to injury, trivial differences were observed for internal loads, distance, acceleration and deceleration. However, a player's four weekly sum of HIR were greater when injured ( $2.36 \pm 2.76$ ) than the uninjured players ( $-0.05 \pm 1.63$ ) at each time of injury. Furthermore, 16 of the 22 participants sustaining HSI were covering significantly more HIR, relative to their 2YWM, in the four weeks leading up to injury than those who remained uninjured ( $p < 0.001$ ). It was also found (Figure 1) that when the four weekly sum was increased it was associated with an increased likelihood of HSI (OR = 1.96, 95%CI = 1.54 – 2.51,  $p < 0.001$ ).

**Discussion:** Previous models have identified the association with high training and match loads and risk of injury, however, the current study has specifically targeted the influence of prolonged HIR on HSI risk. The practical implications arising from these findings may allow for fitness coaches, sports scientists and football club medical practitioners to effectively monitor player's running loads and manage injury risk.

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### Exercise and visceral fat loss: is waist circumference a useful predictor?

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**Introduction:** It is now widely accepted that fat stored around the abdominal organs as visceral adipose tissue (VAT) is more strongly linked to cardiovascular and metabolic disease risk than body weight or total body fat. Studies using computed tomography or magnetic resonance imaging have shown that regular exercise can reduce subcutaneous adipose tissue (SAT) and VAT. However, the ability to measure these outcomes, and therefore the efficacy of an exercise intervention, is limited by the availability, invasiveness and cost of these techniques. Waist circumference is often used as a surrogate measure for abdominal fatness, but there is little data concerning the validity of waist circumference measurement for inferring VAT change with therapeutic interventions. We aimed to examine the efficacy of waist circumference change for predicting abdominal fat change in response to exercise programs delivered according to current recommendations.

**Methods:** Forty five previously inactive and overweight/obese (BMI  $> 25$  kg/m<sup>2</sup>) adults (29-59 y) were randomised to receive 8 weeks of aerobic exercise ( $n=36$ , 30-60 min per session at 50-70% of  $\dot{V}O_{2peak}$ , 3-4 days per week) or resistance exercise therapy ( $n=9$ , 8-10 exercises per session, 8-12 reps, 2-3 sets per exercise at 80-85% of 1-repetition maximum, 3 days per week). VAT and SAT were measured before and after exercise training interventions via magnetic resonance imaging. Change in waist circumference was compared with change in VAT and SAT volumes using Pearson coefficients. Values are reported as means  $\pm$  SE.

**Results:** There was a significant reduction in waist circumference ( $1.9 \pm 0.3$  cm), SAT ( $440 \pm 111$  cm<sup>3</sup>) and VAT ( $259 \pm 55$  cm<sup>3</sup>) with exercise training. There was a weak correlation between change in waist circumference and SAT ( $r=0.322$ ,  $P=0.031$ ). However, there was no significant correlation between change in waist circumference and VAT ( $r=0.190$ ,  $P=0.211$ ).

**Discussion:** These preliminary results suggest that exercise training is effective for reducing visceral adipose tissue in overweight/obese adults. However, change in waist circumference may be a poor predictor of this benefit. Valid, readily accessible options for measuring changes in visceral adiposity in practice are needed.

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### Time-efficient high-intensity exercise improves glycaemic control similarly to moderate-intensity exercise in overweight humans.

AWARD FINALIST

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**Background:** Obesity and physical inactivity are associated with impaired glycaemic control which can lead to insulin resistance and chronic lifestyle disease. While physical activity improves glycaemic control and reduces the risk of disease, 62% of Australians do not achieve the current physical activity guidelines with "lack of time" the most commonly cited barrier. We therefore compared the effect of "time-efficient" high-intensity interval exercise (HIIE) on glycaemic control to that of continuous moderate-intensity exercise (CMIE) in inactive, overweight/obese males and females.

**Methods:** Twenty-seven inactive, overweight/obese participants were matched and randomised into HIIE (9 females, 5 males; mean age 30.3, range 23-38 years; BMI =  $29.2 \pm 5.2$  kg·m<sup>-2</sup>; M $\pm$ SD) or CMIE (8 females, 5 males; mean age 30.4, range 19-40; BMI =  $30.0 \pm 6.6$ ). One hour after breakfast the HIIE group performed a single session of 8x1 minute cycling bouts (100% Wmax) interspersed with 1 minute recovery, whereas the CMIE group performed 38 $\pm$ 1 minutes of continuous cycling exercise (50% Wmax). Continuous glucose monitoring (CGM) was conducted 24 hours before (non-exercise control day) and after exercise (exercise day). Standardised meals for breakfast, lunch and dinner were consumed throughout.

**Results:** Baseline glucose concentrations on the exercise day (HIIE:  $4.72 \pm 0.34$ , CMIE:  $5.05 \pm 0.97$  mmol/l) and non-exercise day (HIIE:  $4.50 \pm 0.38$ , CMIE:  $4.99 \pm 1.03$ ) were not different between groups or intervention ( $p > 0.05$ ). Compared to non-exercise control days CGM data showed similar reductions in average 2h postprandial glucose levels after dinner with HIIE ( $-13 \pm 20\%$ ,  $p < 0.05$ ) and CMIE ( $-8 \pm 12\%$ ,  $p = 0.05$ ). HIIE and CMIE similarly decreased 24h average glucose levels ( $-7 \pm 8\%$ ,  $-4 \pm 6\%$ ;  $p < 0.05$ ), 24h peak glucose concentrations ( $-10 \pm 11\%$ ,  $-10 \pm 13\%$ ;  $p < 0.05$ ), and 24h total glucose area under the curves ( $-7 \pm 9\%$ ,  $-4 \pm 6\%$ ;  $p < 0.05$ ), respectively. The percentage of time spent above 7 mmol/l over the 24h period was decreased with HIIE ( $-2 \pm 2\%$ ;  $p < 0.05$ ). HIIE significantly increased the time spent below 3.9 mmol/l over the 24h period compared to CMIE ( $+16 \pm 17\%$  vs.  $+1 \pm 13\%$ ;  $p < 0.05$ , respectively), coinciding with a significant decrease in time spent between 3.9 and 7.0 mmol/l compared to CMIE ( $-14 \pm 18\%$  vs.  $+1 \pm 15\%$ ;  $p < 0.05$ , respectively).

**Discussion:** HIIE and CMIE both improved glycaemic control in the 24h period following exercise. The HIIE was however  $\approx 38\%$  more time-efficient, consisted of  $\approx 23\%$  less total work (Watts), and increased the time spent with lowered glucose levels over a 24h period. HIIE therefore may be a convenient and physiologically beneficial exercise model to be included in exercise programs for overweight and inactive populations who are at risk of developing chronic lifestyle disease.

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### Improving Muscular Fitness Enhances Psychological Well-being in Low-income Adolescent Boys: Findings from the ATLAS Cluster RCT

#### AWARD FINALIST

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**Background:** Physical inactivity, poor fitness and excessive recreational screen-time may have a detrimental impact on adolescents' psychological well-being, but there is a lack of causal evidence, as the majority of studies have been cross-sectional. Carefully designed experimental studies combined with statistical mediation tests are needed to determine the influence of changes in behaviors and fitness on well-being in young people. The aim of this study was to explore the effect of the Active Teen Leaders Avoiding Screen-time (ATLAS) intervention on psychological well-being in adolescent boys and to examine potential mediating mechanisms.

**Methods:** The intervention was evaluated using a cluster randomized controlled trial in 14 secondary schools located in low-income communities (N=361 adolescent boys, mean age=12.7 $\pm$ 0.5 years). ATLAS was a school-based obesity prevention intervention targeting the health behaviors [i.e., physical activity, screen-time and sugar-sweetened beverage (SSB) consumption] of adolescent boys considered 'at-risk' of obesity. The intervention was delivered over 20 weeks and consisted of teacher professional development, researcher-led seminars, enhanced school sport sessions, lunch-time physical activity mentoring sessions, provision of fitness equipment to schools, a smartphone application and website, pedometers for self-monitoring, and parental strategies to reduce screen-time. Assessments were conducted at baseline and post-intervention (8-months). The primary outcome was psychological well-being, determined using Diener and colleagues' Flourishing Scale. Changes in muscular fitness (timed push-up test), resistance training skill competency (Resistance Training Skills Battery), recreational screen-time (Adolescent Sedentary Activity Questionnaire), and SSB consumption (NSW Schools Physical Activity and Nutrition Survey) were examined as potential mediating mechanisms. Intervention effects and mediation analyses were tested using multi-level linear regression analysis in MPlus.

**Results:** The intervention effect on psychological well-being was small, but statistically significant [unstandardised regression coefficient, C =1.40, standard error (SE) =0.63,  $p =0.027$ ]. In the multiple mediator model that included all of the hypothesized mediators, changes in muscular fitness were significantly associated with changes in well-being ( $p =0.001$ ). Muscular fitness satisfied the criteria for mediation and accounted for 44.0% of the intervention effect on well-being.

**Discussion:** The results of this study provide causal evidence for the beneficial effects of improving muscular fitness in relation to psychological well-being in a sample of adolescent boys from low-income backgrounds. While the primary aim of the intervention was obesity prevention, the results of this study suggest that the ATLAS program had 'spillover effects' in supporting boys' psychological well-being, and that these effects occurred as a result of improvements in muscular fitness.

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### Work-matched high-intensity interval and traditional continuous endurance training similarly attenuate maximal strength gain during concurrent training

#### AWARD FINALIST

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**Introduction:** Simultaneously undertaking resistance and endurance exercise is termed concurrent training, and can attenuate muscle hypertrophy and strength gains compared to performing resistance training (RT) alone. However, the role of individual training variables in this 'interference effect' is unclear. High-intensity interval training (HIT) is a potent stimulus for improving performance and metabolic health markers compared with traditional continuous (CONT) endurance training. However, whether HIT and CONT differentially affect strength and hypertrophy outcomes during concurrent training is unknown.

**Methods:** Twenty-three recreationally-active males were ranked by baseline 1RM leg press strength and randomly assigned to one of three training groups: 1) HIT+RT ( $n=8$ ), 2) CONT+RT ( $n=7$ ) and 3) RT ( $n=8$ ). Participants completed 8 weeks of group-specific training and were assessed for maximal lower- and upper-body strength (1RM leg press and bench press, respectively), maximal lower-body counter-movement jump [CMJ] force/power, and body composition (DXA) before (PRE) and following completion of the training program (POST).

**Results:** Maximal lower-body strength improved from PRE-POST for RT (mean change  $\pm 90\%$  confidence interval; 37.4  $\pm$  9.9%; effect size [ES]  $\pm 90\%$  confidence interval; 1.31  $\pm$  0.3;  $P < 0.05$ ), HIT+RT (27.8  $\pm$  6.0%; ES, 1.13  $\pm$  0.22;  $P < 0.05$ ) and CONT+RT (27.0  $\pm$  5.8%, ES, 0.80  $\pm$  0.15;  $P < 0.05$ ); however, the change between PRE-POST was greater for RT compared with HIT+RT (6.3  $\pm$  9.8%; ES, 0.44  $\pm$  0.54) and CONT+RT (6.5  $\pm$  11.5%; ES, 0.53  $\pm$  0.50).

Maximal upper-body strength improved between PRE-POST for RT (20.0  $\pm$  7.4%; ES; 0.49  $\pm$  1.7;  $P < 0.05$ ), HIT+RT (16  $\pm$  3.1%; ES, 0.62  $\pm$  1.11;  $P < 0.05$ ) and CONT+RT (15  $\pm$  2.9%; ES, 0.40  $\pm$  0.07;  $P < 0.05$ ), and negligible effects were observed for differences in PRE-POST change for HIT+RT compared with RT (-3.6  $\pm$  6.9%; ES, -0.07  $\pm$  0.29) and for CONT+RT compared with RT (-3.5  $\pm$  7.0%; ES, -0.10  $\pm$  0.25).

Peak CMJ force increased from PRE-POST for RT (7.4  $\pm$  5.0%; ES, 0.46  $\pm$  0.29;  $P < 0.05$ ), with this change attenuated for HIT+RT (1.5  $\pm$  2.9%; ES, 0.09  $\pm$  0.18) and CONT+RT (-0.03  $\pm$  14.3%; ES, -0.01  $\pm$  0.74). The PRE-POST change in peak CMJ force was greater for RT compared with HIT+RT (5.5  $\pm$  5.2%; ES, 0.39  $\pm$  0.39) and CONT+RT (11.5  $\pm$  16.0%; ES, 0.77  $\pm$  1.14), and further attenuated for CONT+RT compared with HIT+RT

(-6.4 ±16.6%; ES, -0.41 ±1.09). Lower body lean mass similarly increased between PRE-POST for RT (3.7 ±2.1%; ES; 0.27 ±0.15;  $P<0.05$ ) and CONT+RT (3.5 ±3.0%; ES; 0.39 ±3.4;  $P<0.05$ ), however was attenuated for HIT+RT (1.6 ±3.0%; ES; 0.11 ±0.13).

**Discussion:** These data support the notion that endurance training interferes with maximal strength development when performed concurrently with RT, but extends current knowledge by suggesting that work-matched HIT and CONT exercise do not modulate this effect. Potentially, endurance training volume (i.e., work performed) may be a more critical mediator of the concurrent training effect rather than endurance training intensity *per se*. Future work should investigate the effect of low-volume HIT compared to higher-volume CONT on interference during concurrent training.

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## High-impact, low-repetition jump training is effective for preventing bone loss in postmenopausal regular swimmers

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**Background:** The nature of bone to adapt to mechanical loading is generally acknowledged. High-impact, weight-bearing exercise, especially jump training during childhood to young adulthood, has been shown to increase peak bone mass and may have long-lasting benefits on bone health in later life. However, the effects of high-impact but low repetition weight-bearing training in post-menopausal women has not been defined clearly, yet. The aim of this study was to investigate whether 20 two footed vertical jumps with at least 10 second interval inserted between jumps per day, twice per week for 12 months are effective for postmenopausal regular swimmers.

**Methods:** Forty-four middle-aged post-menopausal regular swimmers (starting mean age, 61.4 years, range 53-73) were divided into two groups: jump training group (n=21) and control group (n=23). The jump training group jumped 20 times with 10 second intervals inserted between jumps per day, twice a week and the total of 40 jumps per week for 12 months. Dual energy X-ray absorptiometry (DXA) was used to measure bone mineral content (BMC) and areal bone mineral density (aBMD) in the lumbar spine and proximal femur. Magnetic resonance imaging determined muscle cross sectional area at the mid-femur.

**Results:** Analysis of covariance (ANCOVA) (with age and body weight change were covariates) revealed that the postmenopausal middle-aged women who undertook the jump training intervention displayed a significantly preserved total proximal femur BMC ( $p=0.024$ ) and aBMD ( $p=0.032$ ) than the control group after 12 months. However, no significant differences were found after 12 months for the DXA determined lumbar spine and femoral neck BMC and aBMD. And also, there were no significant difference in MRI determined muscle cross-sectional area between the jump training and control groups.

**Discussion:** In the middle-aged postmenopausal regular swimmers, high-impact low repetition with rest inserted jump training might be effective for preventing from the bone loss at proximal femur, although the muscle cross sectional area did not affect by the jumping training.

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## Factors affecting performance outcomes for participants in home-based core strengthening programs

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**Background:** Core strengthening programs are designed to improve strength, endurance and stability of the core and are commonly used in injury prevention, treatment, and sports conditioning programs. Home-based core strengthening exercise programs are in widespread use and offer benefits over supervised programs, including reduced costs, greater convenience and improved flexibility for participants however have variable outcomes. There has been limited investigation of factors that contribute to successful outcomes in home-based core strengthening programs. The aim of this study was to investigate factors affecting performance outcomes for both static core endurance and dynamic core stability for participants in a home-based core strengthening program.

**Methods:** 26 participants were recruited to a home-based core strengthening program. Inclusion criteria were 18 years of age or over with a Sahrman test score of level 1 or lower indicating poor core stability. They received an initial instructional class in which they were taught the principles of deep abdominal muscle activation, and how to perform the basic execution, as well as progressions, of all exercises in the program. The exercises were aimed at increasing spinal viscosity, stability and muscle endurance as well as functional training of hip and trunk muscles. Participants were also provided with written and diagrammatic instructions to follow for 2 exercise sessions per week for 8 weeks. Primary outcomes were 3 static core endurance tests (Sorensen, flexor endurance, and side bridge endurance tests), and 2 dynamic core stability tests (Sahrman test for dynamic lumbopelvic stability and Star Excursion Balance test for dynamic postural stability).

**Results:** The participants showed significant improvements in all the static core endurance tests, but not in the dynamic core stability tests. Hierarchical regression analysis showed that only the number of stability ball curl and theraband exercises completed ( $\beta = .83, p<.001$ ), and the participant finding a single instructional session sufficient to learn the exercises ( $\beta = -.791, p=.002$ ) significantly improved the dynamic lumbopelvic stability outcome (Sahrman test).

**Discussion:** Our results show that several factors, including completion of specific exercises and participant perception of the exercise program positively affect dynamic lumbopelvic stability outcomes in a home-based core strengthening exercise program, but are not associated with outcomes related to static core endurance and dynamic postural stability. Therefore improving dynamic lumbopelvic stability appears to be more challenging in an unsupervised environment. Clinicians should consider alternative exercises that are more congruent with being performed without supervision.

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**Introduction:** Exercise is known to be beneficial for bone. As a 10% increase in bone mass developed in youth is predicted to delay the development of osteoporosis by 13 years, optimizing peak bone mass (occurring around the end of the second decade) has been calculated to be the single most important strategy to prevent osteoporosis. One of the most commonly espoused notions in the field of exercise and bone is that physical activity will elicit the greatest adaptive response from the skeleton if applied *prior* to the onset of puberty (Tanner Stage I). The wide acceptance of the assertion however, does not necessarily reflect the strength of the evidence. The goal of the current work was to identify the source and history of the notion, and to set the record straight in terms of the optimal timing of exercise to maximise bone acquisition in childhood.

**Methods:** A review of literature was undertaken to 1. identify literature including a claim about the optimal timing of exercise for bone in childhood, 2. to identify and critically analyse the papers most commonly cited to support the contention that exercise is most osteogenic prior to puberty, and 3. to identify and critically review the balance of the evidence on the topic.

**Results:** The years prior to puberty do not appear to represent a discrete 'window of opportunity' to stimulate bone. The primary source of the misperception appears to have been the interchangeable use of the terms pre-puberty and pre-menarche. In light of the clear difference in hormonal milieu prior to the onset of puberty (Tanner I) versus the early pubertal years leading up to menarche (Tanner 2-3 or 4), and the critical relevance of those hormones to bone development, such a practice is clearly inappropriate. There is considerable evidence to suggest that the *early* (sometimes referred to as *peri-*) pubertal years are a more sensitive 'window of opportunity' to optimise bone mass in childhood than pre-puberty, but also some evidence to suggest there is no specific 'window.' The definitive randomized controlled trial is yet to be conducted.

**Discussion:** The optimal timing paradigm of mechanical loading for bone is unlikely to be prior to puberty. The issue requires redress by way of a large-scale exercise trial including children and adolescents at all stages of maturity.

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**Introduction:** Thoracic bioimpedance cardiography allows for non-invasive estimation of short-term cardiac time-cycles and haemodynamics. These measures may provide insight into cardiac autonomic (sympathetic) activity and are seldom analyzed during post-exercise recovery.

The purpose of this study was to investigate the effect of exercise intensity on post-exercise cardiac time-cycles and haemodynamics.

**Methods:** 11 males (age 30.8±6.4 y;  $\dot{V}O_{2peak}$  51.9±12.7 ml•kg<sup>-1</sup>•min<sup>-1</sup>) cycled for 8-min at three exercise intensities on separate occasions: 45% (LOW), 75% (MOD) and 90% (HIGH) of heart-rate reserve. Thoracic bioimpedance was measured throughout the immediate 10-min of seated recovery. 15-s ensemble-averages were obtained for heart rate (HR), stroke volume (SV) and cardiac output (Q), as well indices that may reflect cardiac contractility and/or sympathetic activity, namely pre-ejection period (PEP), and 'acceleration contractility index' (ACI). These data were analyzed at 1-, 3-, 5-, and 10-min recovery.

**Results:** HR and Q were significantly elevated ( $p < 0.05$ ) above rest throughout recovery for all intensities, except following LOW at 10-min. During recovery, PEP and ACI demonstrated main effects for intensity and time, as well as a time\*intensity interaction. PEP was significantly lower than rest following all three intensities at 1-min (LOW: 75.8±6.3; MOD: 59.7±7.5; HIGH: 54.4±9.5 %rest), 3-min (LOW: 91.2±5.6; MOD: 72.4±11.2; HIGH: 63.1±9.7 %rest) and 5-min (LOW: 94.3±3.4; MOD: 86.1±15.8; HIGH: 73.8±4.9 %rest), but not at 10-min recovery (LOW: 101±2.9; MOD: 95.9±14.2; HIGH: 83.7±17.0 %rest). ACI was significantly higher than rest following all three intensities throughout recovery. PEP was different amongst all three intensities at 1- and 3-min recovery, except for MOD vs. HIGH at 1-min. At 5- and 10-min recovery, PEP was greater during HIGH relative to MOD and LOW. ACI was significantly different amongst all three intensities at 1-min (LOW: 141.7±18.3; MOD: 231.4±58.0; HIGH: 294.4±44.5 %rest) and 3-min recovery (LOW: 121.0±14.6; MOD: 147.2±25.3; HIGH: 196.7±42.9 %rest). At 5-min recovery ACI was greater following HIGH relative to MOD (LOW: 118.7±15.9; MOD: 129.6±22.5; HIGH: 144.6±29.0 %rest). Similarly, at 10-min ACI was greater following HIGH relative to MOD (LOW: 114.1±16.7; MOD 116.6±18.7; HIGH: 136.2±28.6 %rest).

**Discussion:** For this group of healthy males, exercise intensity elicited a dose-response effect on short-term cardiac time cycles and haemodynamic indices during post-exercise recovery. Different impedance-derived indices of cardiac contractility may provide complementary information regarding cardiac sympathetic activity. These non-invasive measures of cardiac sympathetic activity (and their response to acute exercise) may be useful for monitoring autonomic activity, both in clinical and sport performance settings.

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In the cardiovascular system, one of the most important compounds is nitric oxide (NO). Nitric oxide which is formed by the enzyme nitric oxide synthase, is an important regulator of skeletal muscle blood flow and its formation can be induced by a number of mechanical and chemical signals present during exercise. The bioavailability of NO in the cardiovascular system is dependent on the magnitude of reactive oxygen species (ROS) present, as NO rapidly reacts with ROS forming the highly reactive and potentially harmful compound peroxynitrite. In addition, high levels of ROS can lead to an alteration (uncoupling) of nitric oxide synthase, whereby the enzyme produces ROS instead of NO. Evidence for an interaction between NO and ROS has been provided in studies on aged individuals who are believed to have elevated levels of ROS in the vascular system. Such studies show that infusion of antioxidants into the blood can improve the level and function of NO. On the other hand ROS have been shown to be important

signaling molecules for adaptations in response to exercise training. There is substantial evidence for that intake of antioxidants in connection with endurance training can attenuate and even abolish cardiovascular adaptations in response to training. This lecture focuses on the role of NO and ROS for cardiovascular function and discusses evidence for how antioxidants both may promote NO bioavailability and counteract adaptations to exercise training.

## 174 Training and testing the top-class soccer player

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Match analysis and physiological measurements during match play have revealed that modern soccer is highly demanding, and, hence, soccer players need high fitness levels to cope with the demands of the game. This requires appropriate training as well as testing to evaluate the development of the players. The training activities in football should resemble those experienced during the game, e.g. changes of speed, direction and typical movement patterns, so that the specific muscle groups recruited in football are trained and the coordinative, technical and tactical elements are developed under physical demanding conditions similar to those encountered during actual match-play. Thus, studies of soccer players have shown that speed endurance training and aerobic high-intensity performed as small-sided games have a positive effect on high-intensity intermittent exercise performance as evaluated by Yo-Yo intermittent recovery test. Generally, the type and amount of high-intensity training should be game-related and specific to the individual technical, tactical and physical demands imposed on each single player.

## 175 Australian and New Zealand Society of Biomechanics (ANZSB) session

**Introduction:** Biomechanics substantially underpins our understanding of how physical performance may be improved and how injuries may be prevented. The aim of this symposium is to showcase some of the current research being undertaken in the field and to stimulate further discussion about future directions for biomechanics research. The session will consist of 4 papers followed by a panel discussion involving past and present executive members of the ANZSB and the International Society of Biomechanics (ISB). Details of the XXVIth Congress of the International Society of Biomechanics, which will be held in Brisbane in July 2017, will also be provided.

The 4 papers in the session were chosen to give a broad cross-section of some of the innovative biomechanics research currently being undertaken in the region. In Paper 1 ultrasound is used to quantify the 3D changes in shape that occur as a function of increasing muscle contraction intensity. Paper 2 uses ultrasound to quantify foot muscle size in young and older adults and has implications for development of toe deformities and reduced balance in older adults. Paper 3 evaluates the use of a markerless motion capture approach for the non-invasive on-field measurement of athletes during match play. Paper 4 focuses on quantifying the clinical relevance of diminished muscle force control in anterior cruciate ligament deficient, anterior cruciate ligament reconstructed and low back pain populations. Following the four papers, a discussion about the future of biomechanics research will be led by the chairs.

Paper 1: Three-dimensional muscle bulging and its implications for muscle force generation

Paper 2: Using ultrasound to investigate sarcopenia in foot muscles

Paper 3: A markerless motion capture technique for sport performance analysis and injury prevention: toward a 'big data', machine learning future

Paper 4: Clinical implications of muscle force control

## 176 Three-dimensional muscle bulging and its implications for muscle force generation

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**Background:** Muscle bulging, and particularly changes in thickness in pennate muscles, has been suggested to amplify the velocity of contraction by allowing muscle fibres to rotate without changing length. However, it is not clear what governs such shape changes in muscle or the influences this has on the stretch of elastic connective tissues, such as the aponeurosis. The aim of this investigation was to a) determine the viability and reliability of a novel ultrasound imaging method for exploring how muscles in the human lower limb bulge during contractions and b) examine how muscle bulging and aponeurosis stretching influences muscle fibre dynamics at different muscle lengths.

**Methods:** A three-dimensional ultrasound (3DUS) method was used to characterise the in vivo deformation of the human tibialis anterior (TA) muscle at various contraction intensities of isometric dorsiflexion. Subjects (N=12) were seated in a reclined position with their left knee extended and left ankle at 90°. The 3DUS scan involved synchronous B-mode ultrasound imaging and 3D motion capture of the position and orientation of the transducer, while successive cross-sectional slices were made whilst sweeping a transducer from the proximal to distal end of the TA muscle. We examined the intra-session reliability of the muscle volume and length measurements and determined how the muscle bulged in different dimensions by measuring stretch of the internal aponeurosis in both the longitudinal and transverse directions.

**Results:** The 3DUS technique was shown to be highly reliable across measures of muscle volume, muscle length, fascicle length and central aponeurosis length at all contraction intensities (intra-session ICC>0.99 and CV < 2% for all measures). The TA muscle remained isovolumetric across different contraction intensities and progressively shortened along its line of action as contraction intensity increased. This caused the muscle to progressively bulge centrally, as expected. However, the bulging was shown to occur in the thickness dimension at lower contraction intensities, and then in the width dimension at higher contraction intensities. This indicates that changes in muscle thickness (which drive changes in muscle gearing) are dominant at low contraction intensities.

**Discussion:** The results provide the first evidence of how human muscles bulge during contractions and indicate that contraction intensity influences the direction that muscles bulge and the subsequent stretch of the internal series elastic tissue. Further research is required to examine whether factors such as muscle-tendon length can influence force transmission due to variable muscle bulging.

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**Introduction:** Sarcopenia (age-related muscle loss) is a global phenomenon that is worsening due to our aging population. Hence, preserving the independence and physical function of older population should be a primary health priority. Although often neglected, the foot muscles are vital to maintaining physical functioning, whereby toe muscle weakness is an independent predictor of falls in older people. Muscle atrophy has been detected in numerous muscles of the lower limb in older adults, including the triceps surae muscle group. It is speculated that muscles within the feet, including those that control the toes, also suffer from atrophy with ageing. However, there is a paucity of literature characterising foot muscle morphology in older people. Therefore, the purpose of this study was to compare the muscle size of the toe flexor muscles of older adults relative to their younger counterparts.

**Methods:** Forty-one young adults (18-50 years) and 43 older adults (60+ years) were recruited to participate in the study. The abductor hallucis, flexor digitorum brevis and quadratus plantae muscles in the foot and the flexor digitorum longus muscle in the shank were imaged using a Venue 40 musculoskeletal ultrasound system (GE Healthcare, United Kingdom) fitted with a 5-13 Hz (maximum depth 6 cm) linear transducer. Muscle thickness (mm) and cross-sectional area (CSA; mm<sup>2</sup>) were measured using Image J software (National Institute for Health, USA). ANCOVA tests were then used to determine whether muscle size differed between the Young and Old participant groups with gender and BMI used as co-variables.

**Results:** The older adults had a significant reduction in thickness and CSA of most intrinsic foot muscles in comparison to the younger adults. For example, a 25% and 17% reduction in thickness and CSA of the flexor digitorum brevis muscle was evident ( $p < 0.001$ ).

**Discussion:** This study confirms that the size of the muscles that perform toe flexion is reduced in older people compared to their younger counterparts. It is possible that this leads to an imbalance between toe flexor and extensor muscles, and is perhaps the cause the increased prevalence of toe deformities in older people. Sarcopenia appears to affect the size of the smaller foot muscles. This could contribute to reduced toe flexion force production and have a profound effect on the ability of older people to walk safely. Interventions aimed at reversing foot muscle atrophy in older people require further investigation.

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**Background:** Sport biomechanists face a number of unique challenges rarely encountered by clinical or lab based biomechanical researchers. Sporting manoeuvres occur at high speeds with athletes utilising multiple joint degrees of freedom. Subsequently, sport related motion capture, analysis and reporting, requires cutting edge technological solutions for the reconstruction and analysis of high speed complex three-dimensional (3D) motion. From an applied perspective, an ideal solution to 3D sports biomechanical analysis lies in participant specific non-invasive markerless motion capture, enhanced by additional 3D scanning and imaging techniques.

**Methods:** The developed markerless methodology comprises two phases. In the offline calibration and initialisation phase, a static t-pose is acquired of the athlete using a high resolution 3D scanner to create a subject specific reference shape. A skeleton comprising a number of articulated bones and joints is fitted to the 3D model to create a reference rigged template. In the online motion capture phase, a minimum of six 2D video cameras are configured and calibrated to record multi-view 2D videos. A background segmentation algorithm extracts 2D athlete silhouettes in each video frame, which are merged to reconstruct a low fidelity 3D visual hull. Optimisation algorithms extract geometrical data of the visual hull and identify, and segment, each body part. Global joint kinematics are estimated by fitting the reference skeleton to the identified body parts of the curve skeleton. Constrained mesh deformation functions are fed by the global joint kinematics and the resulting error between the surface of deformed model and the visual hull is employed, to adapt and refine the accuracy of the initially estimated joint kinematics.

**Results:** The overall mean error between the 3D scan (reference) and the resulting surfaces (absolute mean of the difference between closest points) varied between 12cm to 16cm across three different postures selected for analysis. This error is reasonable when matching two meshes of 5000 vertices each. The validity of the developed markerless approach was concurrently assessed against a current gold standard marker based using a constant model in OpenSim with lower limb, hip and knee joint angles differences of  $< 2^\circ$  in all planes.

**Discussion:** The overall differences between the aligned reference model and the visual hull confirm that the developed markerless system is capable of estimating accurate joint kinematics in diverse blind body pose estimation scenarios (i.e. sporting activities) and provides an exciting and promising foundation for the non-invasive on-field measurement of athletes during match play.

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**Introduction:** Voluntary muscle force control refers to the ability of the neuromuscular system to produce accurate force output. Following musculoskeletal injury, the accuracy of force generated by muscles surrounding the involved joint(s) is often diminished given agonist and/or antagonist muscle dyskinesia. Our research has focused on quantifying the clinical relevance of diminished muscle force control in anterior cruciate ligament deficient (ACLD), ACL reconstructed (ACLR) and low back pain (LBP) populations.

**Methods:** Participants complete cohort-specific questionnaires (Cincinnati Knee Rating Scale (CKRS) for ACLD/ACLR patients; Oswestry Disability Index (ODI) for LBP patients; visual analogue scale (VAS) for all patient groups) in order to assess disability level and symptoms. Our reliable (i.e.,  $> 0.85$  ICCs) force-matching protocols are performed with participants seated on an appropriate dynamometer (i.e. KinCom or MedX). Sub-maximal

isometric contractions are performed for the muscle group of interest (i.e., extensors of the knee or lumbar spine) at intensities indicative of those utilized during daily living and recreation activities. Whilst observing the target force on a computer monitor, participants contract their muscles to increase and decrease force output at 0.128 Hz within a range of 5–30% maximum voluntary capacity. Force control is quantified by calculating the root mean square error (RMSE) of muscle force relative to the target value.

**Results:** Strength of associations between disability level (as per CKRS or ODI outcomes), symptoms (as per VAS response) and RMSE for the quadriceps or lumbar extensors are calculated using appropriate statistics (i.e. regression or correlation). In ACLD, ACLR and LBP cohorts, we have found that impaired muscle force control is associated with greater self-reported disability levels.

**Discussion:** In addition to being reliable, our tests of muscle force control are valid with respect to self-reported levels of disability in our cohorts of interest. Sinusoidal force-matching tests represent another dimension for assessment of muscle function in ACL injured/ACLR and LBP patients. Aberrant muscle force output may contribute to irregular joint loading and, in the longer-term, progression of degenerative changes including osteoarthritis. Randomized control trials are required to determine the most appropriate intervention(s) (e.g. neuromuscular training) for overcoming muscle force control deficits in these patient groups.

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## Time spent sitting is influenced by neighbourhood crime: Longitudinal evidence from 51,222 Australians

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**Background:** Sitting is an important risk factor for cardiovascular health, cardiovascular disease incidence, and mortality from all-causes and cardiometabolic diseases. While work has focused on breaking up prolonged bouts of sitting, considering upstream structural constraints, such as the social and built environments of where people live, has received less attention. One aspect of social and built environment that intuitively might impact on physical recreation and physical activity is high neighbourhood crime rates. This study examined the association between a change in objectively-measured crime on a measure of sitting time.

**Methods:** Baseline data were extracted from The 45 and Up Study (2006–2008), a large-scale cohort study of health and social phenomena across New South Wales, Australia. Follow-up data from the same participants in 2009–2010 were obtained from the Social Economic and Environmental Factors Study. A total of 51,222 (24,053 men, 27,169 women) with valid outcome data, complete sitting time data, and who did not change their neighbourhood of residence during the study period were included. Sitting time was measured with the question “about how many hours in each 24-hour day do you usually spend sitting?”. Annual crime rate per 1,000 population for each Statistical Local Area (32,000 residents on average) of residence was obtained from the NSW Bureau of Crime Statistics and Research. An overall indicator of outdoor crime (tertiles of low, moderate, and high) was constructed by aggregating each of the counts for non-domestic violence; malicious damage; break and enter; and stealing, theft and robbery. Unobserved bias and multilevel regression models were used to examine association between a change in crime on sitting time, adjusting for potential confounders (age, couple status, income, economic status, physical functioning).

**Results:** An increase in local crime rate was consistently associated with an increase in mean sitting time regardless of gender. The impact was particularly high for an increase in malicious damage from tertile 1 (low) to tertile 3 (high) for men ( $\beta=0.63$ , 95%CI 0.50, 0.77) and women ( $\beta=0.49$ , 95% CI 0.38, 0.61). The odds ratio of daily sitting time of  $\geq 11$  hours was OR=2.69 (95%CI 1.97, 3.67) for men and OR=1.79 (95%CI 1.27, 2.53) for women experiencing a low to high increase in malicious damage. Smaller effects were found for other crime types.

**Discussion:** Increase in the local crime rate has an impact on amount of sitting time. Investments in crime prevention, especially those influencing outdoor and built environment, may have co-benefits for health.

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## Level of physical activity in young children is not related to subsequent motor skill competence

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**Introduction:** Physical activity and motor skill competence are associated cross-sectionally but few studies have investigated longitudinal relationships. The longitudinal studies (in older children and adolescents) show skill competence predicts physical activity. We investigated the reverse i.e. whether physical activity in the toddler/preschool years influences subsequent motor skill competence.

**Methods:** Children were assessed as part of the Melbourne InFANT Program longitudinal cohort study at 19 months, 3.5 years and 5 years. Light-moderate-vigorous physical activity (LMVPA) (accelerometry; any four days) was assessed at 19 months and 3.5 years and at age 5 children were assessed via video using the Test of Gross Motor Development-2 (TGMD-2) on 12 skills. General linear models were performed with either all 12 skills, six object control skills, or six locomotor skills at age 5 as the outcome variable. Model A had LMVPA at 19 months as the predictor and Model B, LMVPA at 3.5 years. Each model adjusted for sex, and age and valid wear time days at the time the physical activity predictor variable was collected.

**Results:** At 19 months, children ( $n = 211$ , boys 51%) engaged in 228 LMVPA minutes per day (range 122 – 353). At 3.5 years ( $n = 129$ , boys 45%) the reduced cohort of children engaged in 310 LMVPA minutes per day (range 192 – 435). At 19 months there was no association between LMVPA and total skill at age 5 ( $B = 0.013$ ,  $p = 0.442$ ). Similarly, at 3.5 years there was no relationship between LMVPA and total skill at age 5 ( $B = 0.030$ ,  $p = 0.139$ ). There was also no relationship between LMVPA at either age when object control and locomotor skill were considered as separate outcomes.

**Discussion:** Based on previous studies our results suggest that skill is more likely to predict physical activity than the reverse. Although it is also probable that the relationship between skill and physical activity is stronger in older children. The children in this sample were only beginning to develop skill and were unlikely to be involved in sports and activities that necessitate skill. Other research has demonstrated ‘free play’ does not contribute much to motor skill competence, so it is suggested that in very young children the type and quality of physical activity relate more to motor skill development than simply movement quantity and intensity. This provides further evidence that young children need specific opportunities for skills to be taught and practised.

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**Introduction:** Identifying cost-effective and efficient methods to attract people to web-based health behaviour interventions is required. Traditional print methods including leaflets, posters and newspaper advertisements remain popular despite the expanding range of web-based advertising options that have the potential to reach larger numbers at lower cost. This study evaluated the effectiveness of multiple web-based and print-based methods to attract people to a web-based physical activity intervention.

**Methods:** A range of print- (newspaper advertisements, newspaper articles, letterboxing, leaflets and posters) and web-based (Facebook advertisements, Google AdWords and community calendars) methods were applied to attract participants to a web-based physical activity intervention in Australia. The time investment, cost, number of first time website visits, the number of completed sign-up questionnaires and the demographics of participants were recorded for each advertising method.

**Results:** A total of 278 people signed up to participate in the physical activity program. Of the print-based methods, newspaper advertisements totalled AUD \$145, letterboxing AUD \$135, leaflets AUD \$66, posters AUD \$52, and newspaper article AUD \$3 per sign up. Of the web-based methods, Google AdWords totalled AUD \$495, non-targeted Facebook advertisements AUD \$68, targeted Facebook advertisements AUD \$42, and community calendars AUD \$12 per sign-up. Although the newspaper article and community calendars cost the least per sign-up, they resulted in only 17 and 6 sign-ups respectively. The targeted Facebook advertisements were the next most cost-effective method, and reached a large number of sign-ups (n=184). The newspaper article and the targeted Facebook advertisements required the lowest time investment per sign up (5 and 7 mins respectively). People reached through the targeted Facebook advertisements were on average older (60 years vs. 50 years,  $p < .001$ ) and had a higher BMI (32 vs. 30,  $p < .05$ ) than people reached through the other methods.

**Discussion:** Overall our results demonstrate that targeted Facebook advertising is the most cost-effective and efficient method at attracting large numbers to population wide interventions, whilst newspaper advertisements, letterboxing and Google AdWords were not effective. The community calendars and newspaper articles may be effective for small community interventions.

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**Introduction:** Multiple lifestyle behaviour interventions are increasingly targeting a broader range of behaviours including sleep and sitting. To assist with participant screening in interventions accurate self-report instruments assessing multiple lifestyle behaviours are needed. The purpose of this study was to compare the accuracy of a self-report instrument assessing sleep, physical activity, sitting and diet over the previous week to criterion measures of these behaviours.

**Methods:** Participants (n=27) wore 3 activity monitors for 5 days: 1) an Actigraph GT3x on their non-dominant wrist, 2) an Actigraph GT3x on their waist, 3) an activPAL3c on their thigh. The wrist worn Actigraph and activPAL3c were worn day and night. Participants also kept a food diary over this time period. At the end of this period participants completed an online survey assessing the number of days in the last week they had good quality sleep, did at least 30 minutes of moderate-to-vigorous intensity physical activity (MVPA), sat for less than 8 hours, consumed 2 serves of fruit and 5 serves of vegetables, and consumed takeaway foods (eg., fast food). Sleep quality was assessed using the Sadeh algorithm, and MVPA bouts in non-sleep periods was assessed using the cut-point of  $>1951$  counts.min<sup>-1</sup>. Sitting time during non-sleep periods was assessed by summing sitting times provided by the activPAL3c. Food diaries were examined to identify the number of days that participants consumed 2 serves of fruit and 5 serves of vegetables, and takeaway foods. Spearman's Rho and Bland Altman plots were used to assess correlations and agreement between self-report and criterion measures of each behaviour.

**Results:** Correlations between self-report and criterion measures of sleep quality ( $\rho = 0.35$ ), sitting ( $\rho = 0.38$ ), and fruit and vegetable consumption ( $\rho = 0.25$ ) were not statistically significant (all  $p$  values  $> 0.05$ ). Correlations between self-report and criterion measures of takeaway food ( $\rho = 0.53$ ,  $p = 0.006$ ) and MVPA ( $\rho = 0.39$ ,  $p = 0.043$ ), were statistically significant. Bland Altman plots showed a tendency for participants to report higher sleep quality compared to the criterion measure.

**Discussion:** Observed correlations varied across behaviours. Some correlations were comparable to those typically reported in the literature (e.g. 0.40-0.57 for MVPA) whereas others were lower (e.g. 0.45 for fruit and vegetable). Further refinement of a convenient and accurate instrument to assess multiple lifestyle behaviours is warranted.

#### AWARD FINALIST

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**Introduction:** Current Australian physical activity (PA) guidelines encourage adults to accumulate 150-300 minutes of moderate to vigorous PA each week. Some critics assert that 300 minutes is unachievable. The aims of this study were to identify the proportion of young adult women who met the 300-minute recommendation over a 12-year period, examine how the 'high active' women achieved this level of activity (in terms of walking, moderate and vigorous activity), and identify the socio-demographic, biological, lifestyle, and work-related determinants of being 'highly active'.

**Methods:** 10574 participants in the Australian Longitudinal Study on Women's Health completed triennial surveys from 2000 to 2012. Baseline age in 2000 was 24.6, range 22-27 years. Self-reported PA was assessed as time spent in walking, moderate and vigorous activity in the previous week; an index of MET.min/week was derived and dichotomised as <1000 MET.min/week (< 300 minutes; not highly active) or ≥1000 MET.min/week (≥300 minutes; highly active). Generalised Estimating Equations were used to examine univariable and multivariable associations of country of birth, area of residence, education, marital status, number of children, body mass index, number of chronic conditions, occupational status, working hours, smoking, alcohol intake, sitting-time and stress, with physical activity status.

**Results:** Across the 12-year period, the proportion of young women who were highly active decreased from 40% in 2000 to 31% in 2012. High levels of activity were achieved through a combination of walking (range 39.1% to 45.1% of total activity) and vigorous PA (range 41.8% to 47.7%). Women who did some activity, but did not achieve high levels, reported proportionally more walking (range 67.8% to 71.8% of total activity), but less vigorous PA (range 13.9% to 16.8%). In multi-variable models, the highest odds for being in the high PA category (ORs ≥1.20; p<0.001) were for women who were single, those who worked long full-time hours, those who drank any quantity of alcohol, and those who sat for less than 8-hours/day. Odds were lowest (ORs ≤0.80; p<0.001) for young women who were obese, those born in Asia and those with one or more children. Discussion These results are the first to show that more than one third of young adult women managed to accumulate 300 minutes or more of PA per week, during a lifestage when most are juggling the demands of work and caring responsibilities. These results show that the recommended upper threshold of the current Australian PA guidelines is achievable.

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### Identification of rural adults at risk of low physical activity levels post cardiac rehabilitation: A cluster analysis

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**Introduction:** Despite advances in health care; there remains significant inequality in cardiovascular health of rural people around the world, with rural populations presenting the highest risk for poor cardiac outcomes in many countries. Cardiac rehabilitation aims to support patients to preserve or assume their proper place in society typically through physical activity and education. Unfortunately, maintenance of physical activity recommendations post cardiac rehabilitation is poor, and worse still in rural adults. There is limited understanding about the factors associated with physical activity behaviour in rural adults beyond rehabilitation. Cluster analysis is a novel, innovative technique that can identify subgroups in data to allow identification and targeting of interventions. The aims of this study were to 1) identify rural adult subgroups based on psychosocial and environmental variables and 2) determine if these subgroups differ in relation to physical activity levels post cardiac rehabilitation.

**Methods:** This cross-sectional study analysed data from 98 rural Australian adults (71% male) aged 41-86 years (mean age = 68.3 years) recruited from The Integrated Cardiovascular Clinical Network South Australia database. A mail-out self-report questionnaire was distributed to a simple random sample of rural South Australians who previously participated in cardiac rehabilitation; 128 questionnaires were returned (40% response rate; n=20 excluded due to missing data). Psychosocial and environmental variables and current physical activity guideline adherence were assessed using the questionnaire. A two-step cluster analysis was conducted on 11 psychosocial and environmental variables. Chi squared analysis was used to compare physical activity guideline adherence across cluster groups.

**Results:** Two stable and meaningful clusters were identified. Cluster 1 (n = 35) was characterised by low levels of self-regulatory self-efficacy, relapse self-efficacy and barriers self-efficacy. Conversely, Cluster 2 (n = 63) had high levels of these same self-efficacy variables. Large effect sizes are apparent when the mean values for the three self-efficacy variables are compared across clusters. Interestingly, none of the remaining eight variables significantly contributed to cluster characterisation. There were significant differences in adherence to physical activity guidelines (p < 0.01), with Cluster 1 less likely to report adequate physical activity levels.

**Discussion:** These clusters could be used to identify at risk rural adults post cardiac rehabilitation. The results highlight the importance of examining how psychosocial and environmental variables cluster and suggest self-regulatory, relapse and barrier self-efficacy should be incorporated into targeted interventions to improve physical activity levels and reduce inequality in cardiovascular health of rural adults beyond cardiac rehabilitation.

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### Factors Associated with Physical Activity Promotion in the Allied Health Setting: A Systematic Review

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**Background:** Physical inactivity (PA) is a leading risk factor for morbidity and mortality. All health professionals have the opportunity and are encouraged to promote PA to their patients. However, little is known about PA promotion behaviour outside general medical practice. This systematic review aimed to identify the factors that are associated with PA promotion behaviour by health professionals other than medical doctors.

**Methods:** A systematic search of five databases was performed for relevant published English-language peer-reviewed evidence of the PA promotion behaviour of health professionals. Studies were included if: participants were practicing health professionals (excluding medical doctors); PA promotion behaviour measures were reported, and a test of association between potential factors and PA promotion behaviour was performed. Two reviewers independently completed study selection, data extraction and quality assessment of each study.

**Results:** Twenty-three studies involving 5673 dental hygienists, dietitians, health care support workers, nurses, occupational therapists, physiotherapists, psychologists and practice assistants were included. Two studies were longitudinal, the rest cross-sectional. All used surveys to collect data. The factors and PA promotion behaviours measured varied considerably between studies. While results were inconsistent, there was evidence suggesting that self-efficacy in PA promotion, positive beliefs in the benefits of PA, personal PA behaviour, assessing patient's PA, PA promotion training and beliefs in the efficacy of PA promotion were associated with PA promotion. The lack of time or remuneration were not considerable barriers to the promotion of PA. A lack of non-responder data, collection by survey only and limited reliability or validity testing of measurements were common limitations of the studies.

**Conclusions:** The factors identified in this review may prove useful in guiding the development and implementation of strategies to encourage greater PA promotion by the broader health professions. Programs, including training, that focus on improving health professionals' confidence and belief in the benefits of PA promotion and improving their own PA behaviours may be warranted. However, the lack of a comprehensive understanding of health professionals' PA promotion, including the absence of studies from a number of allied health professions, and the lack of standardised measures for and clear definitions of PA promotion highlights the need for further research.

## 187 Investigating the meaning of 'gym-going' in an organisational gym.

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**Introduction:** Since the mid-1990s, a number of 'gym studies' have sought to investigate why people participate in gym-going. A central concept of these studies is the body ideal, which is employed to explain why gym-goers perform work on their bodies when they go to the gym. The main findings of these gym studies suggest that people do bodywork to represent the neo-liberal ideal of a healthy, valuable citizen; that is, to secure and symbolise belonging to a particular social class and hopefully (albeit often unrealistically) to attain the ideal body images depicted in the media. The fieldwork as an ethnographer-trainer in an organisational gym revealed that people use this gym for reasons beyond working on their bodies and shaping them according to an ideal.

**Methods:** Ethnographic fieldwork was conducted in the organisational gym over a 12-month period. In addition, 'walk-and-talk' ethnographies with 12 selected gym-goers of the organisational gym were conducted to gain a detailed understanding of why and how people used gym equipment in their gym going and how people personally experience their 'exercising bodies'.

**Results:** A central finding of this study is that body feelings as opposed to body work, are at the forefront of people's experience in this organisational gym. Supporting this finding are exercise logbooks, earphones, and certain items of gym equipment that act as gym 'technologies of the self', which not only assist people to influence their bodies, but also on their memories, minds, thoughts and feelings. The findings also suggest that gym-going is about individuals' socialising 'exercising fleshy bodies'. However, despite the fleshy sociality that constitutes the organisational gym, people are able to temporarily create their 'own' perceived space (s) in this gym, which in turn facilitates a more 'individualised' experience of their gym-going.

**Discussion:** This study provides valuable insight, especially for trainers, to understand that people's gym-going is neither centered exclusively on their bodywork, nor upon attaining a certain bodily ideal. Instead, gym-going involves how people 'exercise' their thoughts and memories, and the degree to which they develop bodily knowledge of how to feel and move their bodies. Based on the central findings, this study calls on gym trainers' pedagogical strategies to understand in more depth why people perform certain gym-going practice, how these practices make them feel and how to incorporate their understanding into the prescription and instruction of exercise at the gym.

## 188 Exploring the minimal, moderate and maximal important differences for the 6 MWT post Total Knee Arthroplasty: which is the appropriate change metric?

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**Introduction:** The six-minute walk test (6MWT) is a commonly used outcome measure to quantify improvement in mobility post total knee arthroplasty (TKA). However, what is considered a clinically important improvement is unknown. The aims of this investigation were to identify the absolute magnitudes of improvement that could be interpreted as minimally, moderately and maximally important, as well as compare the predictive ability of the classifications to determine if there is a most appropriate metric.

**Methods:** Data from a combined randomised trial and observational study investigating the efficacy of inpatient rehabilitation following TKA were utilized. 243 individuals with a primary diagnosis of knee osteoarthritis undergoing unilateral TKA (M= 95, Age 66.75 (SD 8.5), BMI 34.18 (SD 7.12)) were included. Individuals performed a 6MWT approximately 4 weeks prior to surgery and again at 26-weeks post TKA. Post-operatively, patients were asked to rate their perceived improvement in their mobility on a transition scale anchored with "*much better*" and "*much worse*". The threshold for minimal important improvement was identified as the top left corner of a receiver operating curve on data dichotomised into improved or not, with those reporting "*much*", "*moderately*" and "*slightly better*" classified as improved. This analysis was repeated to identify the threshold for moderate and maximal important improvement. The former considered those as "*much*" and "*moderately better*" as improved; the latter only classified those reporting "*much better*" as improved. Area under the curve (AUC), sensitivity and specificity of each threshold were calculated, with AUC comparisons made around the predictive ability of the three classifications.

**Results:** The thresholds were as follows: minimal important difference – 31.5 metres [Sensitivity: 71.54% (95% CI 63.41 to 79.67), Specificity: 66.67% (46.67 to 90.71)]; moderate – 74.5 metres [Sensitivity: 52.21% (41.59 to 61.53), Specificity: 84% (68 to 96)]; maximal -- 36.8 metres [Sensitivity: 75% (65 to 85), Specificity: 34.48 (36.8 to 46.55)]. There was no significant difference in AUC between the three classification strategies ( $p=0.989$ ) and the AUC indicated that the thresholds were poor-to-fair predictors of improvement (67.34%, 67.49%, 60.24% respectively).

**Discussion:** We were able to identify thresholds for minimal, moderate and maximal important improvement in 6MWT distance for TKA patients, however, no threshold classification method was a good predictor of change in our cohort. Our data raise the question whether a patient-perceived minimal, moderate or maximal important difference is possible for the 6MWT in TKA cohort.

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**Purpose:** To optimise the cost effectiveness of MACI, we have developed a new intraoperative procedure (Ortho-ACI™) of seeding chondrocytes onto the type I/III collagen scaffold and reported on laboratory validation of the procedure and clinical outcomes of Ortho-ACI™.

**Methods and Materials:** We tested cell retention on the scaffold by confocal microscopy at 7, 15, 20, 40, 60, 90 and 120 minutes after seeding, and the molecular profile (collagen II, aggrecan, Sox9, HAPLN1) of chondrocytes seeded at 20 minutes and 4 days (preoperative seeding method). Fifteen Ortho-ACI™ patients with 25 cartilage defects were assessed by arthroscopic or magnetic resonance imaging (MRI). Graft repair was graded as excellent, good, poor or no infill. Associations between repair outcome and case variables were also investigated.

**Results:** Intraoperative seeded scaffolds had 79% cell retention at 7 minutes, 97% at 20 minutes and 99% at 90 minutes. Molecular profiling at 20 minutes was more consistent with primary chondrocytes than at 4 days. Most grafts were to patella defects (36%), then medial femoral condyle and trochlea (total 80%). Good or excellent MRI outcomes were noted in 100% of grafts at a mean 25 months follow-up (n=5). Good or excellent second look arthroscopy outcomes were noted in 83% of cases at a mean 17 months follow-up (n=24). Graft-related complications were noted in 29% (7/24) of cases, with all presenting as graft edge tissue overgrowth. Six of these 7 overgrowth cases were graded as excellent arthroscopic repair.

**Conclusion:** The Ortho-ACI™ procedure, utilizing chondrocytes seeding onto collagen scaffold in the theatre, retains viable cells with suitable molecular profile for implantation. With a limited number of cases, Ortho-ACI™ demonstrated good to excellent MRI and arthroscopic repair outcomes. Although more long-term data is needed, the findings of this study suggest that the Ortho-ACI™ procedure is safe, clinically effective and represents an innovative and cost-effective ACI procedure.

AWARD FINALIST

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**Introduction:** There is increasing evidence that patellofemoral pain (PFP) is not self-limiting, with symptoms persisting for up to 20 years. Compounding the burden of PFP is suggestion that PFP may precede patellofemoral joint (PFJ) osteoarthritis (OA). PFJ OA is the most common presentation of knee joint OA, and an important source of knee OA symptoms. Importantly, PFJ OA tends to occur earlier in life than tibiofemoral joint (TFJ) OA. This cross-sectional study investigated: i) the prevalence of radiographic PFJ OA in young to middle-aged adults with chronic PFP; and ii) clinical factors associated with radiographic PFJ OA severity.

**Methods:** 80 participants (51 women; mean±SD age 36±7 years [range 26-50], BMI 25.2±4.3) with chronic PFP (duration ≥3 months) underwent radiographs (weight-bearing anteroposterior, lateral and skyline views) of their nominated knee (most symptomatic eligible knee). Radiographic PFJ and TFJ OA severity were graded using Kellgren & Lawrence (K&L) criteria (0=no OA; 1=doubtful; 2=mild; 3=moderate; 4=severe). Established OA was defined as K&L grade ≥2, with K&L grade 1 classified as early OA. Predictor variables included demographics (e.g. age, BMI); patient-reported outcomes (e.g. pain severity, function, kinesiophobia); clinical tests (e.g. range of motion, strength, functional tests); and patellar alignment (MRI). Predictor variables with significant univariate associations with PFJ OA severity (K&L grade) (Spearman's correlations, p<0.10) were entered into a multivariate backward stepwise linear regression model (p(in) 0.05, p(out) 0.1; significance set at 0.05).

**Results:** 20 participants (25%) had established OA (isolated PFJ: n=14 [18%]; isolated TFJ: n=1 [1%]; combined PFJ/TFJ: n=5 [6%]). 34 participants (42.5%) had early OA (isolated PFJ: n=14 [18%]; isolated TFJ: n=12 [15%]; combined PFJ/TFJ: n=8 [10%]). 26 participants (32.5%) had no OA (K&L 0). Older age (unstandardised b coefficient 0.04, 95% CI 0.02 to 0.07), higher BMI (0.05, 0.01 to 0.1), lower hip external rotation isometric torque (-1.38, -2.64 to -0.11) and higher TFJ K&L grade (0.46, 0.19 to 0.72) were significantly associated with PFJ K&L grade, explaining 40% of the variance.

**Discussion:** One-quarter of young to middle-aged adults with chronic PFP had established knee OA (K&L ≥2), most commonly in the PFJ, and almost half had early OA (K&L 1). While older age and higher TFJ K&L grade are not modifiable, we identified modifiable factors that explained PFJ OA severity. Interventions aimed at reducing BMI and increasing hip external rotation strength may help to slow the onset and progression of radiographic PFJ OA.

## AWARD FINALIST

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**Introduction** Selective atrophy of vastus medialis oblique (VMO) relative to vastus lateralis is considered a clinical hallmark of patellofemoral pain (PFP), despite a lack of supporting data. The aim of this study was to determine if quadriceps atrophy is present in people with PFP, whether VMO was selectively involved.

**Methods** Thirty-five participants with PFP (22 with unilateral and 13 with bilateral symptoms), and 35 asymptomatic control participants matched for age and gender, were measured with real-time ultrasound for quadriceps muscle size. The thickness of the muscles VMO, vastus lateralis, vastus medialis, rectus femoris, vastus intermedius, and the relative thickness of vastus medialis to vastus lateralis were measured. To investigate the prevalence of quadriceps atrophy in PFP, a difference between limbs in the sum of all 5 quadriceps measures > 8.5% was used to define atrophy, and the amount of people with unilateral PFP who had atrophy was recorded. Paired samples t-tests were used to compare muscle size between limbs in unilateral PFP, and independent t-tests were used to compare muscle size between groups with and without PFP.

**Results** The thickness of all quadriceps muscles were statistically smaller in the symptomatic limb of unilateral PFP than the asymptomatic limb (VMO ( $p=0.04$ ), vastus medialis ( $p<0.01$ ), vastus lateralis ( $p=0.01$ ), vastus intermedius ( $p=0.01$ ), rectus femoris ( $p=0.04$ )). No difference was found in the thickness of the quadriceps in people with PFP relative to asymptomatic controls (VMO ( $p=.15$ ), vastus medialis ( $p=.47$ ), vastus lateralis ( $p=0.12$ ), vastus intermedius ( $p=0.47$ ), rectus femoris ( $p=0.50$ )). The relative thickness of vastus medialis, and VMO to vastus lateralis was not different between limbs in people with unilateral PFP ( $p=0.21$ ,  $p=0.83$ ), or between PFP and control group limbs ( $p=0.67$ ,  $p=0.93$ ). Atrophy was found in 45 % of participants with unilateral PFP.

**Discussion** Atrophy of each quadriceps head is present in the affected limb of people with unilateral PFP, but not in PFP when compared to an asymptomatic control group. Selective atrophy of VMO relative to vastus lateralis was not identified in people with PFP. These findings suggest that atrophy of the prominent VMO that is often identified (visually) on clinical assessment may instead represent widespread quadriceps atrophy.

Ultrasound may be used clinically to detect atrophy in unilateral PFP, but not in people with bilateral symptoms. The finding that quadriceps atrophy is common in PFP should be considered when designing rehabilitation protocols for people with bilateral PFP.

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**Introduction:** Patients presenting with patellofemoral (PF) joint osteoarthritis (OA) demonstrate unique clinical features compared with those exhibiting isolated tibiofemoral OA. There is increasing evidence that distinct clinical phenotypes exist within individuals with tibiofemoral OA, which may be associated with their response to non-surgical management. It is unknown whether the same can be said for individuals with PF OA. Therefore, the aim of this study was to examine if baseline characteristics are able to distinguish unique clinical groups of individuals with PF OA.

**Methods:** 88 individuals (M=23, BMI 30.8 kg/m<sup>2</sup> (SD 5.5), Age 42-88 years) enrolled for a multidisciplinary knee OA chronic care program were assessed at baseline. Anthropometry, demographics, emotional state, mobility, goals and disease-specific outcome measures were obtained. Additionally, pain severity, pain location (regional or local), pressure-pain thresholds, lower limb strength and measures of foot mobility and structure were measured on the affected or most painful knee. A cluster analysis was used to determine which variables best separated individuals into clearly defined clinical phenotypes or presentations.

**Results:** There were 3 main clusters and a fourth consisting of the remaining individuals. The first cluster consisted mostly of females who described their pain as "local"; whereby they could point to their site of pain using their index finger. The second cluster also comprised females although they described their pain as "regional"; whereby they required a whole hand to indicate where the majority of their pain occurred. The third group mostly consisted of males describing local pain and the final group was mostly males with regional pain. Further analysis revealed the female-local cluster exhibited significantly lower pressure pain thresholds than the male-regional clusters across 4 local sites and at a proximal testing point (ECRL) (patella: -18.65N 95% CI -34.61 to -2.71), Medial to patella: -14.81N (-28.01 to -1.61), Lateral to patella: -17.99N (-31.3 to -4.69), Proximal to patella: -21.65N (-40.39 to -2.9), ECRL: -12.21 (-23.8 to -0.62)). Emotional state, measured using the EQ-5D and the DASS-21 also appeared to be important at baseline, although their relationships to the actual clinical phenotypes was unclear.

**Discussion:** Preliminary evidence indicates that even at baseline, there are unique clinical presentations of individuals with primarily PF OA. These appear to be based on gender although how patients perceive their pain and psychological factors also appear to be important distinguishing factors. These are potential characteristics that could be used to tailor non-surgical management.

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**Background:** Patellofemoral pain (PFP) is a heterogeneous and often persistent knee condition. More than one third of patients with PFP still report symptoms despite receiving evidence-based treatments that are initially effective. To improve long-term success rates, a strategy is to identify which of clinically assessable patient factors are likely to be most important in predicting successful outcome for an individual patient. This systematic review aimed to comprehensively search of the literature to identify 1) investigate which baseline patient characteristics are associated with a successful or unsuccessful outcome, and 2) whether these patient characteristics are associated with outcomes in response to a specific treatment (treatment effect modifiers) or generically associated with outcomes regardless of treatment (prognostic factors).

**Methods:** Six electronic databases were searched (to June 2014) for studies investigating non-surgical treatments for PFP. Studies were included if they had investigated or reported an association between patient characteristics and outcome. Two reviewers independently assessed papers for eligibility, quality and extracted results. Specified treatment outcome studies were evaluated using a Quality Checklist for Prescriptive, Derivation-based Clinical Prediction Rules.

**Results:** Ten prognostic studies and nine on predictors of outcome after a specified treatment were identified that fitted the search criteria. One hundred and fifty eight characteristics were evaluated with three prognostic studies reporting longer duration of PFP being associated with an unsuccessful outcome regardless of treatment undertaken. Nine studies evaluated one of the following treatments: foot orthoses, lumbopelvic manipulation or patellar taping treatment. They reported multiple factors as predictors of a successful outcome following these treatments. Lower pain scores at baseline and greater foot mobility were the most commonly reported predictors associated with a successful outcome to foot orthoses treatment. Significant methodological limitations were identified in the nine studies of predictors of success from the three specified treatments, which make it difficult to definitively conclude that the predictors confidently predict success following a specific treatment (i.e., are treatment effect modifiers) and not just prognostic factors (e.g., there were no comparator treatments included).

**Discussion:** Clinicians can use the current evidence to help identify patients who are at risk of an unsuccessful outcome regardless of treatment, but not to use it as evidence in support of their ability to predict the outcome to a treatment beyond other potential treatments. Clinicians ought to be circumspect in their application of these findings until such time as there are adequately powered randomized controlled trials that compare relevant treatments.

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## SATURDAY 24 OCTOBER PAPERS AT A GLANCE

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		Evidence Based Guidelines for Safe Transitioning to Barefoot or Minimalist Running	Colm McCarthy		198
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		Does flexibility correlate with crunch factor in golf and produce faster clubhead speed?	Christopher Joyce		200
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		The perceived effect of load carriage on marksmanship in the tactical athlete	Rob Orr		203
		Impact of sport context on the implementation of a self-report measure	Anna Saw		204
		Competitive load of high performing junior basketball players during a national tournament	Scott Talpey		205
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		High-intensity interval training versus continuous moderate intensity training: Effects on health outcomes and cardiometabolic disease risk factors in cancer survivors: A pilot study	Kellie Toohy		208
		Twelve minutes/week of high-intensity exercise significantly decreases aortic reservoir pressure in individuals with metabolic syndrome	Joyce Ramos		209
		Supervised structured exercise training for people with diabetic peripheral neuropathy: a randomised control trial	Michael Kingsley		210
		Cardiorespiratory fitness and not body fat is independently associated with beta cell function in individuals with metabolic syndrome: Fitness versus Fatness	Joyce Ramos		211
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		Testing the effectiveness of prolotherapy compared to physiotherapy for tennis elbow: a randomised control trial.	Leanne Bisset		218
		Achilles tendon is not a single elastic structure: Preconditioning of different regions of Achilles tendon	Leila Nuri		219
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1530-1730	Best of the Best Awards				

J. Hamill<sup>1</sup>\*<sup>1</sup>Biomechanics Laboratory, University of Massachusetts Amherst, USA

Several researchers have led the running discussion in terms what style of running is better, barefoot or shod? Or what type of footfall pattern should be used? The question that most ignore is on what surface is the running taking place. On a hard surface, a habitual rearfoot runner, when running barefoot, generally changes from their habitual pattern to a forefoot pattern to avoid the pain of landing on the heel. This has led to the development of minimalist footwear. However, several running instructors and coaches have extended this concept of barefoot/forefoot running to suggest that the "optimal" footfall pattern to improve performance and reduce running injuries is the midfoot or forefoot pattern. Therefore, it has been suggested that runners, who use a rearfoot pattern, would benefit by changing their footfall pattern although there is little scientific evidence for suggesting such a change. The reasons often given for changing to a midfoot or forefoot footfall pattern are: 1) it is more economical to run with a midfoot or forefoot footfall pattern; 2) there is a reduction in the impact peak and loading rate of the vertical component of the ground reaction force (VGFR) in midfoot and forefoot footfall patterns; and 3) there is a reduction in the risk of a running-related injuries after changing to a midfoot or forefoot pattern. In this presentation, I will critique these suggestions and provide alternate explanations that may provide contradictory evidence for altering one's pattern. We have concluded, based on examining the research literature, that changing to a midfoot or forefoot pattern does not improve running economy, does not eliminate an impact at the foot-ground contact and does not result in reducing the risk of running-related injuries. In addition, the change to minimalist footwear does not necessarily help runners with any of the above factors.

Dr Alex Kountouris<sup>1</sup> • Dr Kevin Sims<sup>2</sup> • Dr Luke Kelly<sup>3</sup><sup>1</sup>Sport Science & Sports Medicine Manager, Cricket Australia • <sup>2</sup>Lead Physiotherapist / Case and Rehabilitation Manager, Cricket Australia • <sup>3</sup>Biomechanist, Cricket Australia

Elite Fast bowlers place substantial physical demands on their bodies, predisposing them to musculoskeletal injury (Orchard 2015), impairing the wellbeing of an individual athlete and overall team performance. A number of factors are known to contribute to injury risk in fast bowlers, including technique (R Portus et al. 2000), age (Johnson et al. 2012) and bowling workload (Orchard, Blanch, Paoloni, Kountouris, Sims, Orchard & Brukner 2015a; Hulin et al. 2014; Orchard et al. 2009). Of the above-mentioned risk factors, arguably the most modifiable, is bowling workload. Accordingly, workload management plans have become an integral component of injury prevention and performance management in fast bowlers. This symposium will provide an overview of how measures of physical workload and athlete wellbeing are incorporated to develop injury prevention strategies in elite Australian cricketers, while also providing insights into the use of wearable technologies to assist in athlete workload management.

AWARD FINALIST

S. Leslie<sup>1</sup>\*<sup>1</sup>MyPhysio Evolution

**Background:** Direction bias assessment (DBA) is a Clinical Pilates concept found to be an accurate predictor of performance after low resistance matched Clinical Pilates exercises. High resistance training is an integral part of any athletes training plan. The purpose of this study was to compare the effect on athletic performance of high resistance exercises matched to an athlete's DBA against a program that contained a mix of matched and unmatched exercises over 4 weeks of strength training and 4 weeks of power training.

**Methods:** Athletes (age 16-44, N = 41) were recruited from local sporting affiliations via advertisement and allocated to either the intervention group of matched direction specific (DS) resistance training (N=21) or the non-direction specific (NDS) group (N=20). All athletes underwent DBA before allocation. Efforts were made in the study to keep training volumes the same across groups. Athletic performance measures were taken for 20m sprint and pro-agility test. 3 hop distance (3HD) and repeated 3 and eight vertical hops (VH) were measured across both bias and non-bias legs. Measures were taken at week 0, week 4 following the 4 week strength program and week 8 following the 4 week power program (both DS and NDS groups).

**Results:** After 8 weeks, the DS group had significantly greater improvements in agility, 3HD (bias side), 3VH and 8VH across both legs ( $p < 0.05$ ). At 4 weeks, the DS group had significantly greater improvements in 3HD (bias side) and 8VH (both sides) ( $p < 0.05$ ). The NDS group did not improve in 3VH or 8VH measures across the 8 weeks, otherwise both groups improved mean scores across all measures across the 8 weeks of programming, though the differences were not significant between the 2 intervention groups unless listed.

**Discussion:** All groups demonstrated improvements across athletic measures following both 4 and 8 weeks of programming. DS gym programming has demonstrated significantly improved athletic measures in the validated tests of pro-agility and 3HD on the bias side over traditional NDS programming. Given that in clinical pilates teachings the bias side is closely correlated to past injury history and reduced performance, preferential improvement of this side would be desirable. Improvements in repeated vertical hop power generation will need further research to validate their impact on athletic performance and/or as a predictor of injury.

J. Scott-Hunter<sup>1\*</sup> • K. Sims<sup>2</sup> • B. Vicenzino<sup>3</sup><sup>1</sup>University of Queensland, Allsports Physiotherapy • <sup>2</sup>University of Queensland, School of rehabilitation Sciences: Physiotherapy • <sup>3</sup>Bupa National Cricket Centre, Brisbane Australia; University of Queensland

**Background:** Throwing athletes attain adaptations in shoulder range of motion (ROM) and strength over time typically involving increases in shoulder external rotation range, reductions in internal rotation and total shoulder ROM, as well as stronger internal rotator and weaker external rotator muscles. These changes in ROM and muscle strength are likely an adaptation to imposed workloads over a protracted period of participation and might contribute to the high incidence of upper limb injuries in throwing athletes. Whether this adaptation occurs soon after a single bout of training is not known. Should a single bout of training produce changes in shoulder range and strength, then strategies that could be implemented at each training session might be useful in injury prevention. The aim of the study was to investigate the acute effects of a cricket fielding session on ROM and muscle strength.

**Methods:** Twelve asymptomatic elite junior male cricketers taking part in a Cricket Australia training program participated in the study. Passive shoulder external and internal rotation ROM measurements were taken using an inclinometer and external rotation strength measured using a hand-held dynamometer. Testing was performed for each participant prior to, immediately following and 24 hours following one of the program's standard fielding training sessions. All participants wore GPS devices in order to provide information on total number of throws performed. A one-way repeated measures ANOVA was performed to determine changes in ROM and strength over the three time points and bivariate correlations performed to establish relationships between ROM changes, strength changes and throwing workload.

**Results:** A significant reduction in shoulder external rotation range ( $M_{diff} = 5.41^\circ$ ; 95% CI [2.97, 7.86]) and total shoulder ROM ( $M_{diff} = 5.42^\circ$ ; 95% CI [2.37, 8.46]) occurred 24 hours following the fielding training session ( $p < .001$ ). There was a negative correlation between external rotator strength and range ( $r = -.71$ ) for changes 24 hours later.

**Conclusion:** External rotation range and total shoulder ROM were significantly reduced following fielding training in elite junior male cricketers and was most marked at 24 hours. There was a relationship between changes in external rotation ROM and external rotator strength 24 hours following the training session. This alteration in range is in contrast to the documented increases in external rotation ROM in baseball pitchers, which might reflect differences in imposed demands between pitching and cricket throwing training.

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**Introduction:** Habitually shod runners may seek to run barefoot, or in shoes with little or no cushioning, to obtain purported benefits including improved performance and reduced injury risk, or simply out of curiosity. Risks of running without cushioning have been reported anecdotally, and in the literature; especially metatarsal stress fractures and calf strains. Based on the available evidence, we present guidelines on how runners might transition to barefoot or minimalist running safely.

**Methods:** We searched medline for studies which involved a training or transition program from using cushioned shoes to running either barefoot or in minimalist footwear, and compared their volume, duration, speed of transition, level of instruction and associated exercise programs. Where available, we reported on drop-out rates and number and type of injuries sustained by participants. To better understand injury risk we compared biomechanical data from studies comparing shod, barefoot and minimalist running.

**Results:** Transition programs in the published literature ranged from 4-12 weeks. Some programs prescribed additional strengthening exercises along with running volumes. Metatarsal injuries were the most common sustained by participants. Based on biomechanical studies, minimalist shoes may pose more of a risk for metatarsal injuries than pure barefoot running, due to spatiotemporal, kinematic and kinetic features they encourage.

**Discussion:** Based on the published literature, we suggest a gradual transition program over 12 weeks. Certain pre-existing medical conditions or physical characteristics may predispose to injury, and should be screened for in prospective converts to barefoot or minimalist running. Using established physiological principles, we suggest a specific ancillary strengthening exercises to accompany a barefoot/minimalist transition program to reduce injury risk.

K. Cohen<sup>1\*</sup> • P. Morgan<sup>1</sup> • R. Plotnikoff<sup>1</sup> • L. Barnett<sup>2</sup> • D. Lubans<sup>1</sup><sup>1</sup>University of Newcastle • <sup>2</sup>Deakin University

**Introduction:** Studies have identified a positive association between fundamental movement skill competency and physical activity in children; however the causal pathways have not been established. The aim of this study was to determine if changes in fundamental movement skill competency mediated the effect of the SCORES intervention on physical activity and cardiorespiratory fitness in children.

**Methods:** Eight primary schools (25 classes) and 460 children (aged  $8.5 \pm 0.6$ , 54% girls) were randomized to the SCORES intervention or control group for the 12-month study. Outcomes were accelerometer-determined moderate-to-vigorous-physical-activity (MVPA) and cardiorespiratory fitness. Hypothesized mediators were actual fundamental movement skill competency and perceived sport competence. Mediation analyses were conducted using multi-level linear analysis in MPlus.

**Results:** From the original sample, 138 (30.0%) and 370 (80.4%) children provided useable physical activity and cardiorespiratory fitness data at post-test assessments. There were significant treatment effects for locomotor skills and overall fundamental movement skills. Changes in MVPA were associated with changes in object-control skills, overall fundamental movement skills and perceived competence. Overall fundamental movement

skills had a significant mediating effect on MVPA (AB=2.09, CI=0.01-4.55). Overall fundamental movement skills (AB=1.19, CI=0.002-2.79) and locomotor skills (AB=0.74, CI=0.01-1.69) had a significant mediating effect on cardiorespiratory fitness.

**Discussion:** Actual but not perceived movement skill competency mediated the effect of the SCORES intervention on physical activity and cardiorespiratory fitness. This provides evidence for the inclusion of fundamental movement skill development as a mechanism of behaviour change, and thus, a strategy that should be included in interventions aimed at increasing children physical activity and cardiorespiratory fitness.

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### Does flexibility correlate with crunch factor in golf and produce faster clubhead speed?

C. Joyce<sup>1\*</sup> • A. Barnett<sup>2</sup>

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**Introduction:** Crunch factor (CF) in golf is the product of lateral bending of the trailing side and axial rotation velocity. CF is maximised at ball impact (BI) and is thought to increase force behind the ball and increase clubhead speed. Investigations have reported dissimilar findings on CF and low back pain although, flexibility and CF have yet to be assessed. The first aim of this study was to see if flexibility (absolute range of motion – ROM) enabled golfers to maximise CF at BI for trunk and lower trunk segments. The second aim was to see if absolute ROM variables helped to produce clubhead speed.

**Methods:** Fifteen male high-level amateur golfers (handicap =  $2.5 \pm 1.9$ ) had their absolute ROM and five-iron golf swings analysed using a 10-camera 3D motion capture system, operating at 250 Hz. A validated multi-segment model was used to analyse kinematics (golf swing and absolute ROM) for trunk and lower trunk segments. A validated launch monitor was used to determine clubhead speed. A bivariate correlation analysis was used to investigate between-segment relationships for kinematic variables. Regression equations were used to determine which absolute ROM variables explained CF for each segment as well as which kinematic variables explained clubhead speed.

**Results:** Bivariate correlation analysis reported moderate correlations of lateral bending at BI and axial rotation velocity for both trunk and lower trunk CF. Five absolute ROM variables reported moderate positive and negative values with trunk CF, lateral bending of the trunk and lower trunk and lower trunk axial rotation at BI. Absolute ROM regression models reported lower trunk flexion and lower trunk CF as significant ( $p=0.006$ ) variables to explain 57.4% variance for trunk CF. A non-significant significant ( $p=0.74$ ) 22.5% model was generated for lower trunk CF. The regression model for clubhead speed reported trunk lateral bending at BI and lower trunk CF as significant ( $p=0.008$ ) variables to explain 63.6% variance.

**Discussion:** Of the five absolute ROM variables, only lower trunk axial rotation was shown to be negatively correlated with CF variables. Trunk and lower trunk flexion and lower trunk left lateral bending were moderately positively correlated with CF variables. These results were reflected in the trunk CF regression model, suggesting flexibility is important in producing CF. However, although lower trunk CF was shown to be a significant variable in explaining clubhead speed, no absolute ROM variables were reported in the clubhead speed regression model.

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### No effect of gluten-free diets on performance, gastrointestinal health or wellbeing in non-coeliac endurance athletes

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**Background:** Implementation of gluten-free diets (GFD) amongst non-coeliac athletes has rapidly increased in recent years due to perceived ergogenic and health benefits. Many athletes self-diagnose gluten-related conditions, self-prescribe a GFD and believe that a GFD improves performance and other parameters (e.g. gastrointestinal (GI) distress). The aim of this study was to investigate the effects of a GFD on exercise performance, GI symptoms, perceived wellbeing, intestinal injury, and inflammatory responses in non-coeliac athletes.

**Methods:** Thirteen competitive endurance cyclists (8 males, 5 females) with no positive clinical screening for celiac disease or history of irritable bowel syndrome (mean $\pm$ SD; age:  $32\pm 7$  years; weight:  $71.1\pm 13.4$ kg; height  $177.0\pm 11.8$ cm,  $VO_{2max}$   $59.1\pm 8.0$ ml.kg<sup>-1</sup>.min<sup>-1</sup>) were allocated to a seven day gluten-containing diet (GCD) or GFD separated by a 10-day washout in a controlled randomized double-blind, cross-over study. Cyclists ate a GFD alongside either gluten-containing or gluten-free food bars (16g wheat gluten per day) while habitual training and nutrition behaviors were controlled. During each diet, cyclists completed the Daily Analysis of Life Demand for Athletes (DALDA) and GI questionnaires (post-exercise and daily). On day seven cyclists completed a submaximal steady-state (SS) 45-min ride at 70% peak power followed by a 15-min time-trial (TT). Blood samples were taken pre-exercise, post SS and post TT to determine intestinal fatty acid binding protein (IFABP) and inflammatory markers (cytokine responses: IL-1 $\beta$ , IL-6, IL-8, IL-10, IL-15, TNF- $\alpha$ ). Mixed effect logistic regression was used to analyze data.

**Results:** TT performance was not significantly different ( $p=0.37$ ) between the GCD ( $245.4\pm 53.4$ kJ) and GFD ( $245.0\pm 54.6$ kJ). GI symptoms during exercise, daily, and DALDA responses were similar for each diet ( $p>0.11$ ). There were no significant differences in IFABP ( $p=0.69$ ) or cytokine ( $P>0.13$ ) responses.

**Discussion:** A short-term GFD had no beneficial or detrimental effect on performance, GI symptoms, wellbeing, intestinal injury or select inflammatory markers in non-coeliac endurance athletes. Based on these findings it is recommended that athletes seek evidence-based advice before adopting a GFD for non-clinical reasons to ensure that nutrition intake supports individualised and optimal fuelling for sport performance.

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### Low carbohydrate intake of masters vs. young triathletes in the pre-competition phase of training

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<sup>1</sup>School of Medical and Applied Sciences, CQUniversity, Rockhampton QLD • <sup>2</sup>School of Human Movement Studies, The University of Queensland, St Lucia QLD

**Introduction:** The sport of triathlon is growing rapidly in Australia with the 2013-2014 *Triathlon Australia* annual report suggesting a 13% increase in participation within sanctioned events over the previous year. Moreover, masters triathletes are a growing cohort both domestically and internationally, with 56% and 47% of male and female finishers at the 2010 Hawaii Ironman over the age of 40 years. Given its endurance nature, triathlon is a metabolically demanding sport. Thus, nutrition plays a major role in exercise performance and recovery. However, little is known about

the nutritional intake of young and masters triathletes during training. Therefore, the purpose of the study was to determine if young and masters triathletes achieve recommended daily macronutrient targets to support recovery from moderate duration/intensity endurance training.

**Methods:** Three-day dietary records were collected from six young (26.8 (25-29) years, 72.0±5.0 kg, 12.4±2.3 h/week) and six masters (54.3 (52-60) years, 78.2±7.2 kg, 13.7±2.3 h/week) male triathletes and analysed for daily macronutrient intake. Athletes were instructed to complete dietary records over two weekdays and one weekend day. Daily macronutrient consumption were averaged over the three-day period and presented relative to body mass. Independent samples and one-sample t-tests were used for between-group comparisons and comparison to macronutrient targets, respectively. Statistical significance was accepted at  $p < 0.05$ . Data is presented as mean ± standard deviation.

**Results:** Masters triathletes consumed significantly less carbohydrate (3.6±0.4 g/kg/day) than recommend by sport nutrition guidelines (7.0 g/kg/day;  $p < 0.05$ ). Similarly, young triathletes consumed significantly less carbohydrate (5.1±1.5 g/kg/day) than recommend ( $p < 0.05$ ). The between-group difference was not significant ( $p = 0.05$ ). Masters triathletes achieved daily protein targets (1.6±0.6 g/kg/day), whereas young triathletes consumed significantly greater amounts of protein (2.4±0.7 g/kg/day) than outlined by sport nutrition guidelines (1.6 g/kg/day;  $p < 0.05$ ). The between-group difference was significant ( $p < 0.05$ ).

**Discussion** The present data suggests amateur triathletes do not consume adequate daily carbohydrate to support recovery from moderate duration/intensity endurance training. Despite the lack of statistical difference, masters triathletes consumed considerably lower amounts of carbohydrate than younger triathletes. Low carbohydrate intakes impair high-intensity training performance and contribute to poor recovery. Furthermore, non-periodised low carbohydrate intake may facilitate longer-term overtraining and/or increase the incidence of musculoskeletal injury known prevalent among masters athletes. Finally, despite masters triathletes achieving sport nutrition targets for daily protein intake, factors such as age-related anabolic resistance may influence protein requirements in this population. In summary, low carbohydrate intake may explain the poor recovery previously observed in masters athletes.

## 203 The perceived effect of load carriage on marksmanship in the tactical athlete

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**Introduction:** Tactical athletes, such as military and specialist police personnel, frequently carry heavy external loads when engaging in marksmanship activities. Although studies have suggested negative relationships between load carriage and marksmanship, there are no known studies comparing subjective expectation (i.e. perception) of marksmanship performance with actual objective measures. The purpose of this investigation was to explore relationships between the perceived effects of load carriage on marksmanship accuracy and objective measures of marksmanship in specialist police officers during an operation-like scenario.

**Methods:** Six men (mean age = 34.0 ± 7.4 years, mean height = 184.2 ± 3.3 cm, mean body weight = 96.3 ± 6.4 kg) from a police Tactical Operations Unit participated in a two-phase investigation. The first phase involved recording objective marksmanship measures for primary (p) and secondary (s) weapons during a short move (Sh) and following a tactical mobility task (Mob) in fatigues only (FO) or tactically loaded (TL) conditions. Marksmanship accuracy was assessed by measuring from the fall of each shot to the centre of target and divided by the number of shots (DCOT). Horizontal and vertical shot dispersion (X- and Y-dispersion, respectively) was the measured distance between the two furthest shots along their respective axis. In the second phase, subjects were asked to assess perceived impacts of load carriage on marksmanship for primary and secondary weapons using a 10 cm visual analogue scale (VAS).

**Results:** There were no statistically significant differences in objective marksmanship measures when TL with either weapon. Officer's perceived that their marksmanship would significantly improve when TL for primary (VAS mean = 3.00 ± 2.53 cm,  $p = 0.016$ ) and secondary (VAS mean = 2.83 ± 2.93 cm,  $p = 0.039$ ) weapons when compared to the FO conditions. While not significant, trends toward negative correlations between perceived improvement in marksmanship when TL and objective measures of marksmanship existed for primary weapon X-dispersion ( $r = -0.561$ ,  $p = 0.247$ ) during the mobility task, and secondary weapon Y-dispersion ( $r = -0.756$ ,  $p = 0.082$ ) and DCOT ( $r = -0.631$ ,  $p = 0.179$ ) during the short move. This means that as perception towards improvement increased, marksmanship measures decreased in size (denoting improved performance).

**Discussion:** Tactical police operators perceive that their marksmanship accuracy is improved when carrying load with objective measures trending toward supporting this belief. Continual marksmanship training while carrying an external load can ensure appropriate confidence in marksmanship performance when carrying load.

## 204 Impact of sport context on the implementation of a self-report measure

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**Introduction:** Athlete self-report measures (ASRM) are a popular method of athlete monitoring in high-performance sports. With increasing recognition and accessibility, ASRM may potentially be utilised by athletes from diverse sport contexts. A key determinant of the efficacy of ASRM implementation is whether or not athletes actually use the measure consistently across a training period. The purpose of the present study was to improve understanding of ASRM implementation across different sport contexts by observing uptake and compliance of a newly implemented ASRM over 16 weeks, and investigating the perceived roles and factors influencing implementation.

**Methods:** Athletes (n=131, 82 male, 49 female) were provided with access to an ASRM for 16 weeks. Athletes completed an electronic survey at baseline and week 16 on their perceptions and experiences with ASRM implementation respectively. Descriptive statistics were calculated for each outcome measure, and analyses of variance were used to compare independent athlete subgroups (recreational (n=25), club-regional (n=79), or national-international (n=24) levels; individual (n=83) or team (n=45) sport; self-directed (n=102) or supported by their coach or sports program (n=26) to use an ASRM).

**Results:** Despite initial interest, only half of the participating athletes attempted to use the ASRM. Of these athletes, supported athletes were most compliant ( $p < 0.001$ ) with a mean compliance of 84 ± 21 %, compared to 28 ± 40 % and 8 ± 18 % for self-directed individual and team sport athletes respectively. Self-directed athletes were motivated to monitor themselves, and rated desired content and minimal burden as key factors for

initial and ongoing compliance. Supported athletes were primarily motivated to comply for the benefit of their coach or sports program rather than themselves, however rated data output as a key factor for ongoing compliance.

**Discussion:** Variability in compliance, how ASRM are perceived by athletes, and the relative importance of influencing factors, highlight the need to tailor implementation strategies according to sport context. In particular, ensuring the measure meets the needs of self-directed athletes with minimal burden, and that supported athletes perceive value from data output. Factors of the measure outweighed those of the social environment regardless of sport context, however the influence of social environmental factors should not be discounted. A well-designed ASRM and a social environment which supports compliant completion by athletes over the long-term presents the greatest potential benefit to athlete preparation for both the individual and sports program.

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## Competitive load of high performing junior basketball players during a national tournament

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**Introduction:** Tournament style competitions are common in sport. In basketball, tournaments for high performing junior players typically consist of several intense competitions within a 1-2 week period. Due to the condensed nature of tournament style competition, time for recovery between games is minimal leaving sports medicine and sport science professionals with a challenging paradigm for the prevention of injuries and the optimisation of performance. The aim of this investigation was to quantify the amount of time junior basketball players spent competing during a national junior basketball tournament. Results from this investigation will help coaches and staff better understand the physical stress of competing in a basketball tournament, and help inform practices to improve player safety during these events.

**Methods:** Competitive load was determined by the amount of minutes played for 72 players from seven teams throughout 2015 Basketball Australia U18 Men's National Championships. Games consisted of 4 x 10 minute quarters. Data were obtained from a publicly available website (<http://www.foxsportspulse.com>) and transferred into Microsoft excel. The mean time spent competing per game and cumulative time spent competing throughout tournament were calculated for each player.

**Results:** Throughout the 8-day tournament each team competed in 1 game per day. The mean amount of time each player spent competing per game was  $20.44 \pm 6.29$  minutes. The mean cumulative time spent competing across the tournament was  $159.55 \pm 54.16$  minutes. However, 30% (n=21) of players participated in  $\geq 200$  minutes of competition during the tournament.

**Discussion:** The volume of competition undertaken by these junior basketball players during the tournament should be considered high. For instance, during the group stages of the 2014 International Basketball Federation (FIBA) World Cup, where games were the same format of 4 x 10 minute quarters, elite senior players competed in five games over a seven day period. The junior players in the current investigation competed in eight games over an eight day period. It is highly likely that high performing junior basketball players would not have access to facilities or staff to ensure rest and recovery practices are optimised. Tournament style competitions present a scenario that conflict with typical best practice regarding the balance between competitive stress and recovery. It is recommended that coaches of high performing junior basketball players competing in a tournament monitor how players are coping with the stress of competition, and plan recovery accordingly.

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## Variability in the sweating rate and sweat electrolyte loss of cricketers during exercise in hot and humid conditions

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**Introduction:** Average sweat rate for cricketers is reported as 0.8-1.4Lhr<sup>-1</sup>. Differences in the intensity of the game and physical demands of players may influence sweat losses leading to considerable variability among athletes. We aimed to investigate the variability in sweat rate and electrolyte losses when euhydrated (EUH) and dehydrated (DEH) during exercise in hot and humid environment in Sri Lanka.

**Methods:** Sweat losses of 3 groups of elite male cricketers (12 fielder, 10 fast bowlers, 8 batsmen; mean age =  $22.2 \pm 2.1$  years) were measured during a 4-hour task specific outdoor training session (temperature =  $30.5 \pm 2^\circ\text{C}$ ; relative humidity =  $76 \pm 8\%$ ). Sweat rate was calculated from change in body mass, taking fluid intake and urine loss into account. Sweat electrolytes (Sodium and Chloride) were measured by chemical analysis of a sample collected from a sweat patch. The measurements were recorded in two separate trials conducted 7 days apart with different hydration levels; EUH trial with  $0.9 \pm 0.5\%$  body mass (BM) loss and DEH trial with  $3.7 \pm 0.8\%$  BM loss.

**Results:** Batsmen recorded the highest sweat rate ( $1324 \pm 148$  ml.hr<sup>-1</sup>; 95% CI 1201 to 1448 in EUH and  $916 \pm 139$  ml.hr<sup>-1</sup>; 95% CI 800 to 1033 in DEH) followed by fast bowlers ( $1231 \pm 176$  ml.hr<sup>-1</sup>; 95% CI 1105 to 1356 in EUH and  $918 \pm 142$  ml.hr<sup>-1</sup>; 95% CI 816 to 1020 in DEH) and fielders ( $1112 \pm 132$  ml.hr<sup>-1</sup>; 95% CI 1028 to 1197 in EUH and  $777 \pm 126$  ml.hr<sup>-1</sup>; 95% CI 697 to 857 in DEH). There were no significant differences in the sweat rate when corrected to body mass ( $p < 0.05$ ). Average sweat sodium and chloride loss for all athletes were  $60.9 \pm 22.4$  mEq.hr<sup>-1</sup> (95% CI 52.5 to 69.3) and  $50.7 \pm 21.1$  mEq.hr<sup>-1</sup> (95% CI 42.8 to 58.6) in EUH trial and  $41.9 \pm 13.1$  mEq.hr<sup>-1</sup> (95% CI 37 to 46.8) and  $29.5 \pm 11.8$  mEq.hr<sup>-1</sup> (95% CI 25.1 to 33.9) in DEH trial respectively. Level of dehydration (% BM loss) was significantly and negatively correlated with the sweat rate (ml.kg<sup>-1</sup>.hr<sup>-1</sup>;  $r = -0.377$ ,  $p = 0.003$ ), sweat sodium loss (mEq.kg<sup>-1</sup>.hr<sup>-1</sup>;  $r = -0.262$ ,  $p = 0.043$ ), and chloride loss ( $r = -0.351$ ,  $p = 0.006$ ). Sweating rate significantly correlated with sweat sodium ( $r = 0.617$ ,  $p < 0.001$ ) and chloride loss ( $r = 0.555$ ,  $p < 0.001$ ).

**Discussion:** Sweat rate of cricketers exercising in hot and humid conditions in the present study was comparable with values already reported in the literature. There is a considerable variation in both the sweating rate and sweat electrolyte losses in relation to the level of hydration. Individualized hydration plans for athletes with an emphasis on electrolyte replacement are recommended for cricketers.

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**Introduction:** Non-alcoholic fatty liver disease (NAFLD), characterised by the excessive storage of fat within the liver, is strongly associated with obesity, cardiovascular disease and type 2 diabetes. There are currently no physical activity recommendations for the management of NAFLD. Several studies have confirmed that regular aerobic exercise can reduce liver fat, however not all individuals who would benefit are able to adopt and adhere to an aerobic exercise program with barriers including co-morbid cardiovascular disease and a fear of falling. Progressive resistance training (PRT) may be an alternative therapy, however the limited available studies have employed "circuit" type resistance training (which has an aerobic component) or non-controlled experimental designs. We therefore aimed to examine the efficacy of traditional PRT, as per current exercise guidelines, compared to sham exercise placebo on liver fat utilising gold standard randomised controlled design.

**Methods:** Nineteen inactive and overweight/ obese (BMI >25kg/m<sup>2</sup>) adults (29-59) were randomised to receive 8 weeks of PRT [n=9, (8-10 exercises per session, 8-12 reps, 2-3 sets per exercise at 80-85% of 1-repetition maximum, 3 days per week)] or a sham-exercise placebo (PLA) control (n=10). Change in liver fat was assessed via proton magnetic resonance spectroscopy (H<sup>1</sup>-MRS). Values are reported as mean ± SE.

**Results:** There was no significant group by time interaction for change in liver fat (-0.17 ± 0.47% in PRT vs. 0.24 ± 0.15% in PLA). No significant changes in weight were observed in either group (gain of 0.30 ± 0.55kg in PRT and gain of 0.33 ± 0.40kg in PLA).

**Discussion:** Results from the present data suggest that traditional progressive resistance training (PRT) is not effective for reducing liver fat in previously inactive overweight/obese adults compared with placebo. While PRT has other known benefits metabolic benefits, an adequate volume of aerobic exercise should be promoted if liver fat is the therapeutic target. The suggested hepatic benefit from circuit-type resistance training may therefore be effectuated by the aerobic component of that mode of resistance training.

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**Background:** It is well established that cancer survivors are at an increased risk for developing cardiometabolic disease (CMD). Currently it is unknown if continuous moderate intensity training (CMIT) or high intensity interval training (HIIT) is more effective in eliminating this risk as such, the aim of this pilot study was to contrast the effects of HIIT versus CMIT on CMD risk and other health related outcomes.

**Methods:** Cancer survivors were randomly assigned into a high (n = 8) or moderate (n = 8) intensity 36 session (12 week) supervised exercise program. The HIIT group performed interval training (≥ 85% maximal heart rate) and the moderate intensity group (MIG) performed continuous aerobic training (≤ 55% maximal heart rate).

**Results:** Significant changes in quality of life (QoL) and waist circumference (WC) in the moderate intensity group (MIG) (QoL p=0.04; WC p=0.03) and QoL, (HC), six minute walk test (6MWT), sit to stand (STS), mean arterial pressure (MAP), central systolic pressure (CSP), pulse pressure (PP), central diastolic pressure (CDP) insulin reduction, hip circumference (HC) and WC (QoL p= 0.01; 6MWT p=0.01; STS p=0.01; MAP p=0.04; CSP p=0.01; PP p=0.02; CDP p=0.04; insulin p=0.03; HC p=0.04; WC p=0.01) in the high intensity group (HIG).

**Discussion:** The results from this pilot study show that high intensity interval training is well received and imparts favourable benefits for exercising cancer survivors. A larger sample size is required to confirm the significance of these findings.

#### AWARD FINALIST

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**Introduction:** Decreased aortic reservoir function leads to a rise in aortic reservoir pressure that is an independent predictor of cardiovascular events (CVEs). We have previously shown that cardiorespiratory fitness (CRF) is independently and inversely associated with aortic reservoir pressure in individuals with metabolic syndrome (MetS). Thus, given that high-intensity interval training (HIIT) is more potent and time-effective in improving CRF compared to moderate-intensity continuous training (MICT), this study investigated the impact of MICT and different volumes of HIIT on aortic reservoir pressure.

**Methods:** Fifty individuals diagnosed with the MetS according to the International Diabetes Federation criteria (Age 56 ± 10 years; hypertensive = 80%; Type 2 Diabetes = 44%; cardiorespiratory fitness [ $\dot{V}O_{2peak}$ ] = 26.2 ± 6.5 mL/kg/min) were randomized into one of the following 16-week training programs: i) MICT (n = 17, 30mins at 60-70% HRpeak, 5x/week); ii) 4HIIT (n = 15, 4x4 min bouts at 85-95% HRpeak, interspersed with 3 min of active recovery at 50-70% HRpeak, 3x/week); and iii) 1HIIT (n = 18, 1x4 min bout at 85-95% HRpeak, 3x/week). Aortic reservoir pressure was calculated from radial applanation tonometry. CRF was also measured via indirect calorimetry during a maximal exercise test.

**Results:** Only 1HIIT significantly decreased aortic reservoir pressure following the exercise program (Pre vs Post: 1HIIT 114 ± 20 vs 107 ± 16, p<0.05; MICT 109 ± 16 vs 109 ± 10, p>0.05; 4HIIT 105 ± 12 vs 110 ± 12 mm Hg, p>0.05). Systolic (SBP) and diastolic blood pressures (DBP) significantly decreased in 1HIIT (SBP ↓7%; DBP ↓5%), and MICT groups (SBP ↓7%; DBP ↓7%), but not in 4HIIT (SBP ↓1%; DBP ↓4%). Only HIIT groups significantly improved CRF from pre- to post-intervention ( $\dot{V}O_{2peak}$ : 4HIIT, ↑17%; 1HIIT, ↑10%; MICT, ↑3%), with no significant difference between groups.

**Discussion:** Twelve minutes of high-intensity training per week was sufficient to induce a decrease in aortic reservoir pressure. Given that 'lack of time' is the most commonly reported barrier to exercise, participation in this low-volume exercise prescription may decrease cardiovascular risk for time-deprived individuals with MetS.

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## Supervised structured exercise training for people with diabetic peripheral neuropathy: a randomised control trial

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**Introduction:** Diabetic Peripheral Neuropathy (DPN) is a serious complication that affects approximately one half of people with diabetes mellitus. DPN is an established risk factor for ulceration and lower limb amputation. Recent quasi-experimental studies provide low-level evidence to support the beneficial effects of exercise on neuropathic symptoms in patients with DPN. The aim of this randomised control trial was to compare the effectiveness of supervised exercise training with an education program on markers of neuropathy for people with DPN.

**Methods:** Twenty-four participants with DPN (54% male; age:  $71 \pm 2$  y; duration of diabetes:  $12 \pm 2$  y) were randomly allocated to either exercise training (exercise) or an education program (education). The exercise group received 3 supervised sessions of low- to moderate-intensity combined aerobic and resistance exercise per week for 8 weeks. The education group received weekly diabetes education sessions for 8 weeks. The primary outcome measure was the Michigan Neuropathy Screening Instrument (clinical signs, score out of 8 and self-reported symptoms, score out of 13). Secondary outcome measures included vibratory perception threshold (VPT) and cardiorespiratory fitness, estimated using a sub-maximal cycle assessment. Baseline and post-intervention values were analysed using mixed-model repeated measures ANOVAs (between: group; within: time).

**Results:** Ten participants in the exercise group and 12 participants in the education group completed the experimental requirements and were included in the analysis. No adverse responses were reported during either intervention. Although the baseline to post-intervention mean differences were greater in exercise when compared to education for all outcome measures, the pattern of response in the primary or secondary outcomes did not differ between interventions (group X time interaction effect:  $p \geq 0.26$ ). Significant improvements were observed in baseline to post-intervention values (main effect of time) for all outcome measures. MNSI clinical signs decreased from 4.5 to 3.5 (MD: 1.0, 95%CI: 0.4-1.7;  $p < 0.01$ ;  $h_p^2 = 0.36$ ) and MNSI symptoms reduced from 4.8 to 3.6 (MD: 1.1, 95%CI: 0.3-1.9;  $p < 0.01$ ;  $h_p^2 = 0.31$ ). VPT improved from 36.8 to 32.5 volts (MD: 4.2, 95%CI: 0.4-8.0;  $p = 0.03$ ;  $h_p^2 = 0.21$ ) and estimated peak oxygen uptake increased from 19.3 to 21.5 ml/kg/min (MD: 2.2, 95%CI: 0.2-4.2;  $p = 0.03$ ;  $h_p^2 = 0.24$ ).

**Discussion:** The results demonstrate that eight weeks of exercise training or lifestyle education can improve neuropathic signs and symptoms in patients with DPN. These findings provide additional support for lifestyle interventions in patients with DPN.

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## Cardiorespiratory fitness and not body fat is independently associated with beta cell function in individuals with metabolic syndrome: Fitness versus Fatness

AWARD FINALIST

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**Background:** The vulnerability of individuals with metabolic syndrome (MetS) to cardiovascular events (CVEs) is negated by increased cardiorespiratory fitness (CRF), despite the presence of obesity as a major component of MetS. Recently, beta cell dysfunction has been linked with increased severity of the MetS. Thus, to better understand the importance of CRF and body fat in treating this condition, we investigated the relationship between fitness and fatness with pancreatic beta cell function indices (disposition index [DI] and proinsulin indices) that are known independent predictors of CVEs. A higher DI represents a better ability of pancreatic beta cells to up-regulate insulin secretion to compensate for reduced insulin sensitivity. Whilst an increased intact proinsulin concentration reflects a reduced ability of pancreatic beta cells to process and excise C-peptide from the proinsulin molecule to produce insulin.

**Methods:** This cross-sectional study included 84 individuals diagnosed with MetS according to the International Diabetes Federation criteria (Age  $56 \pm 9$  years; Males = 64%; Type 2 Diabetics = 42%; cardiorespiratory fitness [ $\dot{V}O_{2peak}$ ] =  $26.5 \pm 6.9$  mL/kg/min; body mass index =  $33 \pm 7$  kg/m<sup>2</sup>). Beta cell function indices were derived from a fasted steady state (basal disposition index [DI], proinsulin, proinsulin:insulin, and proinsulin:C-peptide) and dynamic conditions via an oral glucose tolerance test (1<sup>st</sup> and 2<sup>nd</sup> phase DI). CRF and body fat percentage (BF%) were assessed via indirect calorimetry (during a maximal exercise test) and dual energy x-ray absorptiometry, respectively.

**Results:** CRF was positively associated with basal DI ( $r = 0.40$ ,  $p < 0.001$ ), 1<sup>st</sup> phase DI ( $r = 0.49$ ,  $p < 0.005$ ), and 2<sup>nd</sup> phase DI ( $r = 0.38$ ,  $p = 0.02$ ). Hierarchical multiple regression analysis showed that CRF is associated with basal DI ( $\beta = 0.18$ ,  $p = 0.04$ ), 1<sup>st</sup> phase DI ( $\beta = 0.36$ ,  $p = 0.04$ ), and 2<sup>nd</sup> phase DI ( $\beta = 0.33$ ,  $p = 0.03$ ), independent of BF% and other confounding factors including age, diabetic status, anthropometric measures, lipid profile, and insulin sensitivity. No significant associations were found between CRF and proinsulin measures. BF% was not significantly correlated with any of these beta cell function indices.

**Discussion:** Increased CRF was independently associated with enhanced pancreatic beta cell function. We provide further evidence indicating that CRF is more important than body fatness for function of the pancreatic beta cells in participants with MetS.

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**Introduction:** High intensity exercise loading is required to improve bone mass, but has not traditionally been recommended for individuals with osteoporosis owing to a perceived increased risk of fracture. Current therapeutic recommendations of low to moderate intensity exercise for osteoporosis are of little direct benefit to bone, acting only indirectly to protect from fracture by way of reducing falls. The determination of a targeted, safe, effective, high intensity exercise program to prevent osteoporotic fracture would be a paradigm-shifting advance in a field that has stagnated for the last decade. The purpose of the current study is to determine the safety and efficacy of a high intensity progressive resistance training (HiPRT) program targeted to reduce risk of osteoporotic fracture in postmenopausal women with low bone mass.

**Methods:** Our target is to recruit 100 women over 60 years of age with low bone mass (screened for conditions and medications that influence bone and physical function). The current report includes early findings from the first cohort of participants who have completed the study (n=14). Participants have been randomized to either eight months of twice-weekly, supervised HiPRT or a home-based program of low intensity exercise (CON). Testing is conducted at baseline and 8 months and includes validated measures of functional performance (timed up-and-go test, functional reach test, vertical jump, five times sit-to-stand and back extensor strength (BES)), as well as whole body, lumbar spine and proximal femur, bone, muscle and fat mass (DXA). Compliance and safety is monitored using training manuals, which are completed before each training session.

**Results:** Fourteen postmenopausal women (age 67±6 years; height 162.7±3.9 cm; weight 82.5±9.8 kg) have completed the study to date. HiPRT improved FN BMD compared to CON (+1.0±1.9% vs -3.4±3.6%, p=0.027) and improvements in LS BMD approached significance (+2.0±3.3% vs -1.3±2.8%, p=0.063). Fat mass decreased in CON (-1.43±0.5 kg, p=0.027), while lean mass increased in the HiPRT group (+1.5±0.6kg, p=0.043). BES improved (+83±13%, p=0.014) in HiPRT, but not CON (p>0.05). No significant changes or group differences were observed in any other functional measure (p>0.05). Compliance has been high for both HiPRT (94±12%) and CON (91±3%). No injuries or adverse events have occurred as a result of training.

**Discussion:** Although preliminary, findings suggest that supervised HiPRT provides a greater stimulus to bone and muscle than a traditional home-based low intensity exercise program. The program appears to be a safe and appealing therapeutic option for postmenopausal women with osteoporosis.

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**Background:** This demonstrated the effectiveness of eccentric exercise in the rehabilitation of Achilles tendinitis, on pain and function, but not known, the biomechanical changes that occur in the tendon, which can explain this evidence.

**Methods:** A group of 17 healthy men, with 43.76 ± 8.03 years performed eccentric exercise training of plantiflexors with one leg and concentric exercise training with the other leg, working at a submaximal load, average volume and moderate speed during eight weeks, 5 times a week. Outcome measures included plantiflexors moment of force, elongation (stereophotogrammetry and ultrasound measures) and stiffness of Achilles tendon.

**Results:** we found that stiffness of Achilles tendon decreased significantly from 29.8 N / mm (± 11.8) to 25.7 N / mm (± 9.7) (P <0.007) in the leg working eccentrically and increased from 22.1 N / mm (± 9.6) to 24.6 N / mm (± 9) (P <0.004) in the leg working concentrically.

**Discussion:** Our results showed that eight weeks of eccentric training with submaximal loads, decreased Achilles tendon stiffness in healthy individuals, by contrast, concentric exercise training was related to an increased Achilles tendon stiffness. Effect of eccentric training on tendon stiffness, has been previously studied by Mahieu et al., (2008) and Morrissey et al., (2010), who despite using a similar methodology, found different results. Mahieu et al., (2008) conducted a randomized, controlled, pre-test – post-test to assess effects of eccentric training for 6 weeks (74 volunteers), and found significant change in stiffness after this training, but also found increasing range of motion in ankle dorsiflexion and decreased passive resistance.

Possible explanations to Mahieu et al., (2008) results, could be that there was tendon adaptation to eccentric exercise with sub-maximum load; tendons become more elastic in response to repeated elongation in downward movement of the heel, until reaching its maximum dorsiflexion range. Morrissey et al, (2010) conducted a randomized, pre-test – post-test, to assess effects of eccentric and concentric training during 6 weeks (38 volunteers), they found decreased tendon stiffness in the eccentric group, but there were not significant changes in the concentric group. We conclude that these changes are probably related to tendon structural plasticity in response to the repetition of eccentric movement in the complete range of planti-dorsiflexion

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Tendinopathy is frequently associated with structural disorganisation, and the use of imaging can assist in diagnosis, with a number of studies outlining good-to-excellent accuracy, sensitivity and specificity of conventional imaging in the diagnosis of tendinopathy. Despite this, the clinical diagnosis of tendinopathy can be unclear, for example patellofemoral pain can present with pain at the inferior pole similar to patellar tendinopathy. While imaging shows the presence and extent of structural changes within the tendon, the clinical interpretation of the images requires context in regards to the features of pain and the aggravating loads. This is due to the limited relationship between structural disorganisation and pain; similar to other musculoskeletal conditions such as osteoarthritis and intervertebral disc degeneration.

The advent of new imaging modalities allowing for the quantification of tendon structure has allowed for insight of the features of tendon pathology; critically, that the pathological Achilles and patellar tendon adapt to areas of structural disorganisation by increasing in tendon dimensions with aligned fibrillar structure. This has major implications for the rationale for treatment of tendinopathy (ie. build load capacity in the present aligned fibrillar structure) and the monitoring of tendon pathology, where stable tendon structure may be a positive outcome.

This presentation will focus on the clinical use of imaging for tendinopathy; for diagnosis, monitoring of structure following treatment and injury prevention. The presentation will summarise the current research and clinical experiences and provide a framework and clear criteria for clinicians for the use of imaging in tendinopathy.

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## Repeatability and Agreement of Digital Image Correlation (DIC) for Regional Strain Estimates of the In-Vivo Human Patellar Tendon

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**Background:** In-vitro research has shown that strain variations occur within and along the fibers of the patellar tendon. Consequently, it has been hypothesised that these variations may contribute to the occurrence of patellar tendinopathy and may explain the specific localised lesion that occurs with the pathology. DIC is a non-contact image processing method that applies a correlation function to features in successive ultrasound images to estimate strain under dynamic and high-load conditions within an identified region of interest. The primary aim of this study was to assess the methodology of applying DIC to estimating localised strain behavior of the patellar tendon. Specifically this study assessed 1) between-trial and between-day repeatability; and 2) the level of agreement of the DIC estimates with an accepted manual point-to-point method.

**Methods:** Seven adult subjects (5 males, 2 females; age = 30.5 +/- 3.5 y) performed a rate controlled voluntary ramped contraction to a normalised target torque over a specified rate with simultaneous collection of sagittal plane imaging of the patellar tendon and knee extensor torque using real time B-mode ultrasonography and dynamometry, respectively. Each subject was examined at a high (rate1) and low (rate2) loading rate. Ultrasound images were subsequently processed using specialized software to estimate strain at selected regions.

**Results:** Intraclass correlation values for between-trial and between-day strain estimates were greater than 0.88 ( $p < 0.95$ ). The average mean detectable change for DIC estimates across testing rates was 1.16% (0.52-2.08%) ( $p < 0.95$ ). Limits of agreement analysis report there was a 95% likelihood that DIC values were within  $\pm 0.59\%$ , and 0.45% of the manual method for rates 1 and 2, respectively. DIC was found to overestimate reported strain by 0.19% for rate1 and 0.06% for rate2. Both rates were found to have an  $r^2$  value of 0.99 ( $p < 0.95$ ).

**Discussion:** Results show DIC to be a feasible and repeatable approach for estimation of regional strain at the patellar tendon. The accuracy and repeatability of DIC does not appear to be affected at the two rates assessed in this study.

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## The Sympathetic Nervous System and Insulin Resistance in Achilles Tendinopathy

AWARD FINALIST

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**Introduction:** Tendinopathy is a common musculoskeletal condition, which has been linked to metabolic diseases such as type 2 diabetes mellitus (T2DM). A recent systematic review identified evidence of increased sympathetic nervous system (SNS) markers in the paratendinous tissue and tenocytes of painful tendons. Prospective studies demonstrate that increased SNS activity predicts future development of insulin resistance (IR) and T2DM, and this is a potential explanation for the link between tendinopathy and metabolic diseases. No studies have explored *in vivo* measures of the SNS or IR in human tendinopathy. Therefore, this study aimed to compare *in vivo* measures of the SNS and IR between individuals with Achilles tendon pain and those without.

**Methods:** This case-control study included 15 participants with Achilles pain and 22 participants with no history of tendinopathy. *In vivo* SNS activity was measured at rest using microneurography to record muscle sympathetic nerve activity (MSNA). Achilles tendon structural integrity was quantified using ultrasound tissue characterisation (UTC). Glucose and insulin values obtained from the oral glucose tolerance test were used to calculate *in vivo* IR (Matsuda index).

**Results:** The case group had 6 women and 9 men, while the control group had 9 women and 13 men. Demographic data, including age (cases median = 30 years, controls = 24), body mass index and blood pressure were not significantly different between groups. The median pain duration in cases was 24 months, ranging from 1 month to 33 years. There were no group differences in MSNA ( $p = 0.264 - 0.774$ ). However, there was a significant correlation between tendon pain duration and MSNA burst frequency ( $R^2 = 0.324$ ,  $p = 0.027$ ) and burst incidence ( $R^2 = 0.408$ ,  $p = 0.010$ ) in cases. There was no association between UTC and MSNA data, however, excluding an unexplained outlier revealed a mild association between poor tendon structure and increasing MSNA, but only in cases (burst incidence  $R^2 = 0.476$ ,  $p = 0.006$ ). Measures of IR were not associated with tendon pain or structure.

**Discussion:** This study indicates that SNS activity is not elevated in individuals with Achilles tendinopathy. However, in those with tendinopathy, SNS activity was associated with duration of symptoms. The association between pain duration and SNS activity indicate that the SNS may play a role in the chronicity of tendinopathy. IR was not involved with tendinopathy in this metabolically normal population and may only become involved at extreme levels (e.g. T2DM).

## AWARD FINALIST

E. Rio<sup>1\*</sup> • D. Kidgell<sup>2</sup> • M. van Ark<sup>3</sup> • H. Zwerver<sup>3</sup> • I. Sheek<sup>3</sup> • G L. Moseley<sup>4</sup> • J. Gaida<sup>5</sup> • S. Docking<sup>1</sup> • J. Cook<sup>1</sup><sup>1</sup>Monash University • <sup>2</sup>La Trobe University • <sup>3</sup>University of Groningen • <sup>4</sup>University of South Australia • <sup>5</sup>Canberra University

**Introduction:** Patellar tendon pain is at its highest in-season but there are no published data of successful management when athletes are playing and training. Furthermore, there are changes to the cortical control of the quadriceps in patellar tendinopathy (including excess quadriceps inhibition) that may not be ameliorated with current loading protocols. Strength training that is externally paced with either visual or auditory cues may not only have positive effects on tendon matrix and muscle properties but may exploit the processes leading to neuroplasticity and improve control of the muscle. The aim of this study was to compare two forms of strength training designed to affect cortical control, during a competitive season, for the effects on tendon pain and cortical inhibition.

**Methods:** This was a randomised clinical trial with two intervention arms. Sub-elite and elite basketball and volleyball athletes aged over 16 years, playing and training three times per week, were recruited and randomised to either isometric or isotonic exercise. Protocols were completed four times per week for four weeks on a leg extension machine. Protocols were matched for time under load and rest between sets, isometric consisted of; 5 x 45 seconds at 60 degrees and isotonic consisted of; 4 x 8 (three second concentric and four second eccentric phase). Strength training was externally paced using an audio recording specifically designed for the study. A subgroup of athletes completed testing of cortical control of the quadriceps.

**Results:** Twenty-nine athletes were recruited. Median pain scores improved significantly over the 4-week intervention period in both the isometric group (pre 5.5/10, post 2/10,  $p=0.012$ ) and isotonic group (pre 5/10, post 2.5/10,  $p=0.003$ ). However, the isometric group reported significantly greater immediate pain relief following each intervention session ( $p<0.002$ ). Cortical testing, ( $n=9$ ) showed that isometric and isotonic training reduced quadriceps inhibition by 41.3%.

**Discussion:** This study provides clinicians with successful two in-season interventions for patellar tendinopathy. For immediate pain relief, it appears that isometric exercise is superior but both programs were efficacious over the four week block. Isometric and isotonic exercise programs are easy-to-use exercises that can reduce pain from patellar tendinopathy for athletes in-season. Both protocols used externally paced strength training, termed tendon neuroplastic training, which incorporates parameters important for tendon loading but importantly, may contribute to modifying the cortical control of the quadriceps muscle.

L. Bisset<sup>1\*</sup> • M. Yelland<sup>1</sup> • M. Ryan<sup>1</sup> • S. Ng<sup>1</sup> • D. Rabago<sup>1</sup><sup>1</sup>Menzies Health Institute Queensland, Griffith University

**Introduction:** Chronic lateral epicondylitis (LE), also known as 'tennis elbow', is a common and costly type of tendinopathy primarily of the common extensor tendon of the elbow. Approximately 20% of all tendinopathy cases are recalcitrant to conservative treatment, leaving these patients with little recourse other than living with the condition or progressing to surgery. Prolotherapy is an emerging injection therapy thought to stimulate tendon repair and has demonstrated some efficacy in the Achilles tendon. A specific physiotherapy program is known to be effective in both the short and long-term in people with LE. The aim of this randomised controlled trial is to examine the short-term clinical effectiveness of prolotherapy (Prolo) alone, and in combination with physiotherapy, compared to physiotherapy alone (PT).

**Methods:** 120 participants with a clinical diagnosis of LE were randomised by concealed allocation to one of three treatment groups: Prolo, Prolo+PT, or PT. Prolo comprised a series of four injections of dextrose delivered at monthly intervals. PT comprised four sessions of manual therapy and exercise over a 4-week period. Blinded follow-up assessments occurred at baseline and 12 weeks follow-up. The primary outcome measure was the change in Patient Rated Tennis Elbow Evaluation (PRTEE) and self-perceived global improvement, from which success was calculated. Analyses were conducted on an intention-to-treat basis using linear mixed and logistic regression models.

**Results:** 120 (62 men; mean age  $49.8 \pm 7.8$  years) participants were enrolled in the study and 109 (91%) completed the 12-week follow up. There was a significant effect of Time ( $p<0.001$ ) but no Time x Group interaction ( $p=0.2$ ) for PRTEE. PRTEE scores significantly improved from baseline to 12 weeks follow up by 16 (95% CI 9.9 to 22.5) points for Prolo, 21.9 (95%CI 15.6 to 28.3) points for Prolo+PT, and 23.7 (95%CI 16.8 to 30.7) points for PT.

There was no difference between groups for success at 12 weeks ( $p=0.7$ ), with 46% in the Prolo, 54% in Prolo+PT and 56% in the PT group reporting their condition as either much improved or completely recovered.

**Discussion:** Overall, there was no difference in outcomes between prolotherapy injections and physiotherapy, and no added benefit in combining the two treatments. There is a need for cost evaluation and long-term follow up assessment to determine whether the short-term improvements are maintained.

## AWARD FINALIST

L. Nuri<sup>1\*</sup> • R. Newsham-West<sup>1</sup> • M. Ryan<sup>1</sup><sup>1</sup>Griffith University, Centre for Musculoskeletal Research

**Background:** Preconditioning is a process where successive standardized cyclic loading is applied to the tissue in an attempt to produce a consistent and repeatable mechanical response. Recent biomechanical studies demonstrated that two different regions of Achilles tendon (AT) (e.g., proximal AT and free AT) exhibit different elastic behavior during submaximal contraction of plantarflexors. However, these studies have not addressed whether or not these regions exhibit different viscoelastic behavior during cyclic preconditioning. Freehand three-dimensional (3D) ultrasonography (US) has recently been described that provides a reliable and high fidelity assessment of in-vivo human AT tissue elasticity. The present study aimed to use 3DUS to investigate the preconditioning process of the free AT, proximal AT and whole AT (e.g., free AT + proximal AT) experiencing 70% maximal voluntary isometric contraction (MVIC) in vivo.

**Methods:** Eleven healthy male adults (means  $\pm$  SD for age, height, and weight were 28y, 177.63cm, and 76.72kg respectively) were positioned prone on a test bench, with their left knee and hip at full extension and left ankle at 90°. The 3DUS scan involved synchronous B-mode ultrasound imaging and 3D motion capture of the position and orientation of the transducer while successive cross-sectional images were collected by sweeping a transducer from the base of the heel to medial gastrocnemius muscle tendon junction in a transverse orientation at a steady speed. Scanning was performed at rest and during 10 successive ankle plantarflexion movements at 70% of their MVIC. The resultant ultrasound images were imported into *Stradwin* software (Cambridge, UK) to render a 3D reconstruction of AT for the measurement purposes. For each trial, AT strain was calculated as the ratio (%) of tendon elongation relative to the resting length.

**Results:** There was a significant main effect of contraction numbers on free AT and whole AT strain response, with no changes obtained after the second and the third contraction for the respective regions. Furthermore, significant reduction in free AT and whole AT compliance was observed following successive trials. Regarding the proximal AT strain, no significant difference was found between contractions.

**Discussion:** The different preconditioning response across the free AT, proximal AT and whole AT documented in this study supports previous studies reporting non-uniform strain distribution between two regions of the human AT. This finding may have important implications for standard warm up and preconditioning protocol of AT in athletic, research, and clinical communities.

## AWARD FINALIST

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**Introduction:** Achilles tendinopathy is prevalent in the sedentary and athletic population. Recently, the association between plantaris and the Achilles tendon (sometimes invaginated in the same sheath) has been implicated in the development of midportion tendon pain. Surgical excision of the plantaris tendon has been shown to be effective in the reduction of pain and return to activity. While promising clinical results have previously been reported, this study focused on changes in tendon structure, as quantified by ultrasound tissue characterisation, in relation to clinical outcomes.

**Methods:** 15 elite athletes with Achilles tendon pain and loss of function were diagnosed with an invaginated plantaris tendinopathy using ultrasound tissue characterisation (UTC). UTC allows for 3-dimensional imaging of the Achilles tendon and quantification of tendon structure. Patients underwent an Alfredson surgical procedure with the invaginated plantaris excised and surgical separation of the ventral fat pad from the tendon. VISA-A scores (questionnaire on Achilles tendon pain and function out of 100) were recorded pre- and post-surgery. The mean cross-sectional area (mCSA) of aligned fibrillar structure (echo-type I and II)(AFS) and disorganised tissue (echo-type III and IV)(DIS) were quantified pre- and post-surgery.

**Results:** Mean VISA-A scores prior to operation were 48.7 $\pm$ 10.2 (mean $\pm$ SD) and improved significantly 6-months post-surgery (94.6 $\pm$ 4.0) ( $p\leq 0.05$ ). No significant differences were observed in the mCSA of AFS (pre-94.1 $\pm$ 36.3mm<sup>2</sup>, post-104.2mm<sup>2</sup> $\pm$ 39.6mm<sup>2</sup>(median $\pm$ IQR);  $p\leq 0.05$ ), mCSA of DIS (pre-11.5 $\pm$ 11.4mm<sup>2</sup>, post-4.8 $\pm$ 5.1mm<sup>2</sup>(median $\pm$ IQR);  $p\leq 0.05$ ) and total tendon mCSA (pre-105.6 $\pm$ 46.8mm<sup>2</sup>, post-112.5mm<sup>2</sup> $\pm$ 43.2mm<sup>2</sup>(median $\pm$ IQR);  $p\leq 0.05$ ). The mCSA of AFS pre- and post-surgery was greater than that previously reported in structurally normal tendons.

**Discussion:** Excision of the closely associated or invaginated plantaris tendon significantly improved clinical outcomes as has been shown in previous studies. However, improvements in clinical outcomes do not appear to be mediated by changes tendon structure. This surgical procedure may be efficacious by removing compression on the Achilles by the plantaris tendon and/or disrupting the ventral nerve supply. As these tendons contain sufficient amounts of aligned fibrillar structure, this surgical treatment may reduce pain and allow for increased load capacity in the adequate levels of aligned fibrillar structure.

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**Introduction:** Pelvic pain, particularly pudendal neuralgia, is one of the most widespread yet least known and understood afflictions facing people today. Over the last ten years and after treating nearly 6,000 patients, the author has found that many conditions that may have resisted traditional medical treatment, such as pain in the scrotum, labia, perineum, anorectal region, penis, dysuria, urinary and faecal urge incontinence, pain during or after ejaculation or climax, and sexual and erectile dysfunctions are often associated with pelvic girdle dysfunctions involving the sacroiliac joint and impacting on the pudendal nerve.

**Methods:** In this presentation, the author presents his anatomy study and introduces a new map of the pudendal nerve, and he also outlines methods and level 2b evidence treatment for the pelvic dysfunction and management of symptoms. In particular, he establishes the role of posture and lumbar-pelvic mechanics, exercise, mobilising techniques of the sacroiliac joint and addresses the phenomenon and management of neural hypersensitivity.

**Results:** The findings of this study suggest that a subgroup of patients with pudendal neuralgia can have a significant reduction in symptoms following musculoskeletal management of the lumbar pelvic region.

## 222 Psychiatric input into the assessment and management of chronic pelvic pain

L. Hamilton<sup>1\*</sup>

<sup>1</sup>Thoughtful Health, QLD

Psychiatric assessment of chronic pain includes first exploring the patient's own understanding of their pain experience and expectations of treatment. Many patients may have fear of an underlying serious disease or pathology. Chronic pain can challenge a person's self-identity, and may be linked to themes of trauma, regret or blame.

A psychiatrist will explore a patient's cognitive models to identify unhelpful patterns of thought. Catastrophising is associated with the internal belief that pain is overwhelming and unmanageable, and components of this include rumination, magnification and helplessness. A fear-avoidance pattern is associated with increased disability and increased risk of pain chronicity.

Management will include psychoeducation about the emotional components of pain. Therapy can assist the patient to develop more adaptive coping mechanisms, and to work through issues of grief, loss, role transition or relationship difficulties.

Patients with chronic pain can evoke strong countertransference in the treating therapist and it is important that the therapist develop an awareness of transference and countertransference reactions in order to maintain a therapeutic relationship with the patient. Patients with chronic pain often feel a sense of moral judgement, and effective treating relationships are those which provide validation and recognition.

Sexual trauma is a difficult and complex area. Most women with pelvic pain have not been abused, but abuse, particularly in childhood, is associated with an increased risk of chronic pelvic pain. When a history of trauma is present it may complicate the treatment of chronic pain. Sexual dysfunction is common even in patients with no history of trauma, and this leads to further problems with relationships and intimacy.

## 223 Persistent Pelvic Pain

P. Hall<sup>1\*</sup>

<sup>1</sup> St Andrew's Pelvic Medicine Centre, Spring Hill, QLD

Women with persistent pelvic pain (PPP) can present a major challenge for clinicians to provide comprehensive care. The symptoms are frequently multi-system and vary with each system and vary over time. Multiple co-morbidities are often present, making a diagnosis, appropriate investigations and the offering of treatments difficult. Care readily becomes fragmented.

Gynaecologists are frequently the first specialists involved. This presentation will consider the various diseases producing acute pain that eventually may turn into persistent pelvic pain.

The place of diagnostic and therapeutic surgical interventions will be discussed.

The role of medication, botulinum toxin and nerve blocks and sacral neuromodulation will be explored.

## 224 Interventional Pelvic Pain Management

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Persistent Pelvic Pain has historically been and continues to be a condition which is difficult to definitively diagnose and manage for specialists, GP's and allied health professionals.

Pain Medicine is an exciting and rapidly evolving area of research. In 2011 Clifford Wolff first described central sensitisation and its implications for diagnosis and treatment. We are now beginning to get a clearer understanding of how early in the pelvic pain experience, central sensitisation begins to occur. In managing pelvic pain, we are also presented with the unique challenge of viscerosomatic and viscerovisceral hyperalgesia.

I will discuss medical and interventional management, however these therapies without the support of a multidisciplinary team and a good GP rarely provide long term functional improvement.

Coordinated multidisciplinary care remains best practice and I will outline the role of the Specialist Pain Medicine Physician within this team.

## 225 Heart-Rate Variability Threshold, a valid alternative for Ventilatory Threshold Testing and Training purposes?

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**Background:** Although spiro-ergometry is the established 'gold standard' for determination of the second ventilatory threshold (VT<sub>2</sub>), it is a costly and rather time-consuming method. Previous studies suggest that assessing the second anaerobic threshold (AT<sub>2</sub>) on the basis of heart rate variability (HRV) during exercise may be a more cost-effective, practical and non-invasive technique. Appropriate validation studies, however, are lacking.

**Aim:** To test the reliability and sensitivity of the second HRV threshold (HRVT<sub>2</sub>) assessment method against VT<sub>2</sub> in healthy young adults.

**Methods:** Eleven healthy, moderately-trained subjects underwent three incremental exercise tests until exhaustion. Ventilation, oxygen uptake, CO<sub>2</sub> production and beat-to-beat R-R interval were measured continuously. Exercise testing was performed in three oxygen (F<sub>i</sub>O<sub>2</sub>) conditions of inspired air (14%, 21% and 35% of oxygen) in a randomized fashion. Participants were blinded to the F<sub>i</sub>O<sub>2</sub> conditions. Heart rate variability (HRV) was quantified every 30 seconds by first calculating the root mean square of successive differences of R-R intervals (RMSSD). Normalized RMSSD (nRMSSD) was obtained by subsequently dividing RMSSD by the average R-R interval over the corresponding 30s period. HRVT<sub>2</sub> was assessed and defined as the breakpoint representing the start of a substantial increase in nRMSSD, after having reached a minimum value. VT<sub>2</sub> was defined by the second nonlinear increase of the V<sub>e</sub>/VCO<sub>2</sub> curve. Two research teams, blinded for the F<sub>i</sub>O<sub>2</sub> condition, assessed VT<sub>2</sub>s and HRVT<sub>2</sub>s independently from each other. Agreement between HRVT<sub>2</sub> and VT<sub>2</sub> was determined by Bland and Altman analysis. Differences between the 3 conditions were determined by a General Linear Model for repeated measures.

**Results:** Mean workloads corresponding to VT<sub>2</sub> and HRVT<sub>2</sub> in hypoxia were shifted to the left and were respectively 19±17 % (p=0.05) and 20±22% (p=0.05) lower in comparison with hyperoxic conditions. Bland and Altman analysis showed low estimation bias (2.7%) and acceptably precise 95% limits of agreement for workload (-15.1% to 20.5%).

**Discussion and Conclusion:** Although there is currently no gold standard for determining AT<sub>2</sub>, our HRVT<sub>2</sub> assessment showed acceptable agreement with VT<sub>2</sub>. Furthermore, it also showed similar sensitivity to hypoxic exercise conditions. The cost-effectiveness and efficiency of the HRV-based method may therefore make it suitable for endurance and altitude training purposes.

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## Determination of glycaemic fluctuations with continuous glucose monitoring. What is a meaningful difference?

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**Introduction:** Glucose metabolism is an important contributor to cardio-metabolic health status and a key indicator of diabetes. The aim of this study was to determine daily fluctuations in glycaemic control and assess the suitability of continuous glucose monitors (CGM) to measure change to clinical interventions.

**Methods:** Nine apparently healthy individuals consented to wearing a CGM (Medtronic iPro2) for five consecutive days. Participants were required to maintain usual physical activity patterns and replicate dietary intake each day. Participants used Optium Xceed glucometers to measure capillary glucose up to four times each day for calibration of the CGM. Data were downloaded onto a computer and area under the 24-hour glucose curve calculated using the trapezoidal model.

**Results:** Participants had a mean±SD age of 20.9±2.3 years, were 169.8±7.7 cm tall and weighed 71.7±13.4 kg. All individuals were healthy with a mean±SD plasma glucose of 4.7±0.3 mmol·L<sup>-1</sup>. The mean (95% CI) for 24-hour glucose area under the curve (AUC) on the first day of wear was 1558 (1323 – 1793) mmol·L<sup>-1</sup>·24h<sup>-1</sup> and related samples Friedman test failed to detect a statistically significant difference across the five days of CGM wear (p = 0.89). The mean difference in 24-hour glucose AUC was calculated by subtracting the subsequent days of wear from the initial day of wear (i.e. day 2 – day 1; day 3 – day 1) to examine the level of daily fluctuation. Mean (95% CI) difference between the first and second wear days was 246 (-48 – 541) mmol·L<sup>-1</sup>·24h<sup>-1</sup> and median (P25-75) was 273 (-74 – 379) mmol·L<sup>-1</sup>·24h<sup>-1</sup>, Friedman test revealed no significant difference between the four change scores (p = 0.90). Individual coefficient of variation scores confirm this finding and range from 0.05% to 20% across all individuals on all days of wear. As there was no statistical difference across days, all change scores were combined to calculate an overall mean (95% CI) change in 24-hour glucose AUC of 289 (187 – 392) mmol·L<sup>-1</sup>·24h<sup>-1</sup>.

**Discussion:** Glucose AUC data from CGM is extremely stable across several days in apparently healthy individuals. Therefore, it can be concluded that glucose AUC from CGM is a reliable measure of glycaemic regulation in individuals who have no challenges with glucose metabolism and that changes in glucose AUC of 25% of baseline values will represent a clinically meaningful change in glucose metabolism in response to either exercise, nutritional or medical interventions.

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## The brain of an elite athlete: Do physical training adaptations extend to the brain?

AWARD FINALIST

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**Introduction:** Prolonged mental exertion (ME) compromises endurance performance in moderately-trained participants. The impact of ME on elite athletes is unknown. This study sought to determine whether characteristics, specific to elite athletes, affect the impact of ME on physiological, psychological and performance variables.

**Methods:** Nine elite road cyclists (6 AIS world touring squad members, 3 national level cyclists) and nine recreational level cyclists completed 30 min of an incongruent Stroop colour-word task, previously used to induce mental fatigue in recreational runners, or 30 min of a passive control task in a double-blind cross-over study. Following each treatment, participants completed a standardised warm-up and 20 min cycling time trial (TT). Physiological and psychological measures were recorded throughout the tasks and TT. Two- and three-way repeated measures ANOVAs determined interactions and differences between tasks, level of cyclist and time.

**Results:** The Stroop task was rated more mentally demanding (p<0.01,  $\eta^2$ p=0.88), requiring more effort (p<0.01,  $\eta^2$ p=0.90) and being more frustrating (p<0.01,  $\eta^2$ p=0.89) than the control task. The elite cyclists saw no difference between tasks for mean power (p=0.98,  $\eta^2$ p<0.01), average speed (p=0.48,  $\eta^2$ p=0.07) or total distance (p=0.49,  $\eta^2$ p=0.07). Relative to control, the recreational cyclists recorded reduced mean power (p=0.01,  $\eta^2$ p=0.55), slower average speed (p<0.01,  $\eta^2$ p=0.68) and less total distance (p<0.01,  $\eta^2$ p=0.63) following the Stroop task. Blood glucose tended to increase in the elite cyclists during the Stroop task (Pre: 4.9±1.0 to Post: 5.6±1.2 mmol·L<sup>-1</sup> p=0.06,  $\eta^2$ p=0.38). Perception of effort (RPE) was not different between conditions for either level of cyclist.

**Discussion:** The Stroop task was rated as equally demanding between levels of cyclist, however, thirty min of ME impaired TT performance in recreational cyclists, while the elite cyclists were unaffected. The decrement in performance associated with ME is attributed to greater RPE, due to increased cerebral adenosine. Adenosine accumulates under periods of increased energy demand and reduced energy availability. Training-induced increases in cerebral glycogen have been observed in rats following endurance training. A parallel adaptation in elite cyclists may explain the increase in glucose concentration throughout the Stroop task. An enhanced supply of fuel would mediate accumulation of adenosine and its effect on RPE and performance. Given the consistent detrimental effect of ME on endurance in recreational populations, it is likely that elite cyclists possess training-induced adaptations that allow for a degree of resistance to ME. Training to enhance these adaptations could be exploited to maintain performance in both physically and mentally demanding situations.

## 228 The effect of age on muscle strength recovery following an anaerobic exercise stimulus

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**Introduction:** There has been an increasing number of masters athletes continuing to train and participate in organized sporting events over the past 30 years. These masters athletes that have shown that the declines of physical capacity seen in a normal ageing population may be less closely linked to the ageing process and more closely linked to an increasing sedentary lifestyle. Despite new research into the performance of masters athletes, little is known about the recovery kinetics of this population. Therefore, the aim of this study was to compare muscle performance recovery after an anaerobic stimulus in performance-matched younger and masters cyclists.

**Methods:** Eight young (age = 25.3 ± 2.5 yrs, height = 176.6 ± 6.5, weight = 79.63 ± 3.6) and nine masters (age = 55.5 ± 5.4 yrs, height = 177.9 ± 9.1, weight = 81.0 ± 8.9) cyclists volunteered to participate in this study. Fatigue was induced by an anaerobic cycling protocol consisting of 6 x 30sec efforts at 175% of maximal aerobic power with 4.5mins rest between efforts. Muscle performance and recovery was assessed by peak torque values of the knee extensors during isometric contractions at a knee angle of 90° at baseline, 2hrs post fatigue, 24hrs post fatigue and 48hrs post fatigue. A two way repeated measures ANOVA was performed to compare between testing conditions (time point vs group).

**Results:** Both young and masters peak torque values showed similar levels of fatigue at the 2hrs post fatigue mark (5.3% and 7.8%, respectively). However, there was no significant interaction between age and time ( $F(3,45) = 0.133$ ,  $p > 0.05$ ) and no significant within group differences in the fatigue and recovery of muscular performance for younger ( $F(3,21) = 1.063$ ,  $p > 0.05$ ) or masters ( $F(3,24) = 2.266$ ,  $p > 0.05$ ) cyclists.

**Discussion:** This investigation found that following an anaerobic cycling protocol levels of muscular fatigue and recovery were similar between younger and masters trained cyclists. The findings of this investigation align with the current literature that suggests when masters athletes undergo muscular fatigue their recovery is not impaired relative to a performance matched younger cohort.

## 229 Quantifying airflow and volume from differential pressure using a Venturi tube

P. Titheradge<sup>1\*</sup> • R. Robergs<sup>1</sup>

<sup>1</sup>Charles Sturt University

**Introduction:** Ventilation meters such as pneumotachometers and turbine flow meters have fragile and sensitive moving parts that make them susceptible to damage from accidental impact, thus delaying ongoing research. These devices can cost between \$4000 to \$6000 to purchase, as well as additional costs with ongoing maintenance. The purpose of this study was to apply the physics of fluid dynamics through a Venturi tube (Vt) to the measurement of air flow at rates that span the human physiological range, with the purpose to document the efficacy of the Vt for applications to the measurement of human ventilation.

**Methods:** Air flow from 0.1 to 8 L·s<sup>-1</sup> was measured using a pressure transducer sensitive from 0 to 1,000 Pa combined with a custom Vt made from retail PVC tubing (50 mm inside diameter (ID) at inlet, 17.5 mm ID throat section). A Turbine impeller (Ti) flow meter was used as the criterion method. Airflow conditions were produced by a commercially available air-compressor and 3 L calibrated syringe. Agreement between the Vt and Ti was assessed by Bland-Altman plots, with added association quantified by linear and non-linear regression. Integrated volume from Vt and Ti was compared using an unpaired t-test, with significance accepted at  $p < 0.05$ .

**Results:** The Vt produced valid volumetric airflow estimates across non-steady state pulsatile flow conditions produced by a 3 L-calibrated syringe (+/- 0.22 L·s<sup>-1</sup> 95% confidence limits with zero bias for Bland-Altman). The Vt estimates for steady-state continuous flow produced by an air-compressor resulted in high precision (+/- 0.065 L·s<sup>-1</sup> 95% confidence limits with zero bias for Bland-Altman). An unpaired t-test revealed Vt volume estimation at different flow rates (0.1 to 8 L·s<sup>-1</sup>) to be similar to the criterion Ti volume measurements (2.972 +/- 0.02 vs. 3.066 +/- 0.022 L for Vt and Ti, respectively), though with less than half the percentage error (0.9 % vs. 2.2 %, respectively).

**Discussion:** Both the Turbine and Venturi meet the < +/- 3% minimum error required by American Thoracic Society standards for spirometers. The validity of Venturi volumetric airflow and volume calibration clearly indicates the potential for valid measurements in human ventilation, such as airflow (L·s<sup>-1</sup>), tidal volume (V<sub>T</sub>) and minute ventilation (L·min<sup>-1</sup>). Each of these measures are influential in the science of indirect calorimetry and subsequent measurements of whole body VO<sub>2</sub> (L·min<sup>-1</sup>), VCO<sub>2</sub> (L·min<sup>-1</sup>) and RER (respiratory exchange ratio).

## 230 Absolute and relative training demands of international female rugby sevens players

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**Introduction:** Training camps are used to prepare players for the unique demands of rugby sevens tournaments due to decentralised programs that some rugby sevens teams still experience. The focus of training camps is to maintain player's physical capacities as well as develop technical

performance of essential skills and team tactics. It is also important to monitor the players during training camps, to minimise the risk of overtraining and injury and to optimise performance at upcoming tournaments. As there is no data available on the physical demands of rugby sevens training camps, the aim of the present study was to quantify the absolute and relative training demands of training camps for international female rugby sevens players.

**Methods:** Twenty four international female rugby sevens players (age  $24 \pm 5$  years, height  $168 \pm 5$  cm, body mass  $68 \pm 6$  kg) were monitored over seven training camps using global positioning system units with integrated tri-axial accelerometers. Training camps consisted of four sessions over two to four days, to prepare players for international competition. Data for the four sessions was reported as an overall average of a training camp session, with each session also compared using effect sizes.

**Results:** Female rugby sevens players covered a total distance of 3776 m or a relative distance of 2625 m/hour during an average 87 minute session of a training camp. Total distance consisted of 194 m (132 m/hour) of high-intensity running and 59 m (40 m/hour) of sprinting. Forty one sprints occurred on average during a training session with 29 sprints occurring per hour. Repeated sprints occurred 15 times during training camp sessions at a rate of 11 per hour.

A large effect size decrease between training sessions was observed for the absolute number of sprints between sessions 3 to 4. Moderate effects were also observed between absolute and relative repeated sprints with an increase from session 2 to 3 and a decrease between sessions 3 and 4.

**Discussion:** The total distance covered during female rugby sevens training camps is equivalent to approximately two and a half international female matches. While the total distance is covered over 87 minutes, the absolute training load reflects the tournament structure of rugby sevens and the need to play multiple games a day. The monitoring of training camp data will assist coaching staff to further improve the periodised design of training camps to optimise team performance for upcoming tournaments.

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### The effects of different menstrual cycle phases on urinary biopyrrin excretion following 2-h prolonged exercise

N. Yasuda<sup>1\*</sup> • T. Tanioka<sup>2</sup>

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**Background:** Urinary biopyrrin levels, which are oxidative metabolites of the antioxidant bilirubin, have been proposed as a useful biomarker of oxidative stress following exercise. However, no data are available with respect to the effects of two different menstrual cycle phases on exercise-induced oxidative stress. The purpose of this study was to clarify the effects of the follicular and luteal phases on urinary biopyrrin levels after 2-h cycling exercise.

**Methods:** Thirteen recreationally active eumenorrhic women [age:  $20.9 \pm 0.3$  year; height:  $160.5 \pm 5.7$  cm; body weight:  $55.3 \pm 5.6$  kg; body mass index:  $21.5 \pm 1.8$  kg/m<sup>2</sup>; body fat:  $21.9 \pm 3.1$  %; peak oxygen uptake ( $VO_{2peak}$ ):  $44.9 \pm 4.9$  ml/kg/min (mean $\pm$ SD)] participated in this study.

To determine their  $VO_{2peak}$ , all participants performed an incremental cycling exercise until volitional exhaustion. The participants carried out the same submaximal exercise protocol during the follicular (F: 5–8 days after the onset of the menses) and luteal (L: 22–25 days after the onset of the menses) phases. Each participant performed 2-h submaximal cycling exercise corresponding to a constant power output at 60% $VO_{2peak}$ . In order to prevent hypoglycemia and dehydration, carbohydrate-electrolyte solution were consumed every twenty minutes (2 ml/kg body mass) during each exercise protocol. Spot urinary samples were taken before (Pre) and after (Post) 2-h cycling exercise for the later analysis of the urinary biopyrrin levels which were determined with an enzyme-linked immunosorbent assay.

**Results:** No significant differences were observed (Pre= $0.86 \pm 0.30$ , Post= $0.85 \pm 0.27$ , Post-24h= $0.88 \pm 0.16$  for F; Pre= $0.87 \pm 0.27$ , Post= $0.86 \pm 0.20$ , Post-24h= $0.88 \pm 0.19$  for L, U/g creatinine) between the follicular and luteal phases at the urinary biopyrrin levels following submaximal exercise.

**Discussion:** Previous studies have demonstrated oxidative stress between follicular and luteal phases, but results have been conflicting. The findings of the current study suggest that the follicular and luteal phases appear to be similar after 2-h moderately prolonged exercise at the urinary biopyrrin levels in recreationally active eumenorrhic women.

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### Symposium: Improving recruitment, compliance, adherence and maintenance in physical activity interventions in adults.

W. Brown<sup>1\*</sup>

<sup>1</sup>The University of Queensland

**Introduction:** There are many innovative ongoing PA trials in Australia which are focussing on improving activity patterns (ie increasing physical activity, decreasing or breaking up sitting time). Many of these trials share common challenges in terms of recruitment, compliance and maintenance of behaviour change. These issues are however rarely reported in the papers that present study outcomes.

**The symposium:** In this interactive symposium, researchers who are in various stages of testing PA intervention strategies for adults will share the strategies they have used to encourage recruitment, to foster compliance with behaviour change protocols, to prevent attrition, and to encourage maintenance of change once the intervention finishes. Projects using a range of settings (eg corporate offices, universities, hospitals and health services, blue collar workplaces, parks and whole communities, etc) will be used as examples, and the roles of behaviour change models (including those that include intrinsic and extrinsic motivation strategies) will be considered. As 'results' will not be presented, this will not be a series of papers, but an interactive 'problem solving' discussion.

**Conclusion:** Participants will learn about ideas for improving recruitment, compliance, adherence and maintenance in physical activity trials in adults.



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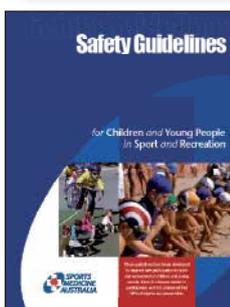
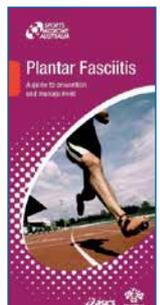


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