



The Journal of Sport & Exercise Science

THE OFFICIAL JOURNAL OF SESNZ

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SESNZ

SPORT & EXERCISE SCIENCE

— NEW ZEALAND —

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Sport and Exercise Science New Zealand

Annual Conference, 27-29 November 2019 Massey University, Palmerston North

Hosted by the School of Sport, Exercise and Nutrition at Massey University

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Welcome

Welcome to the 2019 Sport and Exercise Science New Zealand Annual Conference at Massey University! After holding the last conference on the South Island we make a welcome return to the North Island this year and we are delighted that the team at Massey University agreed to host this year's conference. We very much look forward to catching up with you at the conference over the next two days. Don't forget to join us for a social function at the Distinction Coachman Hotel on Thursday 28th November from 5.30pm onwards.

It has been an exciting year for SESNZ and 2019 has seen a further increase in our membership; the launch of our Journal on our website - The Journal of Sport and Exercise Science (ISSN 2703-240X) as a free to submit, open access international journal; further work with ACSM, BASES, ESSA and CSEP on an international Alliance for sport and exercise science; finalisation of our accreditation processes for all accreditation pathways; and the launch of our new look website. Please ask anyone from the Board if you would like to discuss any of these developments during the Conference.

We would like to take the opportunity to thank all of you as delegates for attending, whether you are presenting or attending to enjoy some of the excellent presentations that will be made during the conference. It is exciting to see the growth in attendance to the conference being made year on year and this year's growth has meant that we are able to create interest streams due to the increasing popularity of the conference.

Good luck to all the presenters and don't forget, if you are a student, to register for the student prizes - for the best oral presentation and poster presentation, which will be awarded on Friday afternoon. A big thank you also goes to our sponsors and helpers who include: gbc BioMed, VX Sport, COSMED, Otago Polytechnic, Routledge, Netball NZ, and Australian Catholic University, and, our gratitude to Andy Foskett and Toby Mündel and all the team at Massey University.

As a dates-for-your-diary, we are very pleased to confirm that the 2020 SESNZ Conference will be held in Christchurch at the University of Canterbury (25th - 27th November 2020) and the 2021 SESNZ Conference in Auckland at Auckland University of Technology (likely dates, TBC, 24th-26th November 2021).

It is always a team effort to make a conference run, so thank you to everyone involved at Massey University for their work behind the scenes to getting things ready for our annual get together. A warm welcome to all and please do not hesitate to contact any of the Board with feedback suggestions or ideas for the future. If you would like to get involved with the direct work of SESNZ and the Board we would be delighted to hear from you as well.



Nick Draper

Chair, SESNZ Executive Board

Programme

SESNZ Conference, 27th-29th November 2019, Massey University, Palmerston North

Day One: Wednesday 27 th November (Wharerata)	
15:00-	Registration
17:00-18:00	Refreshments (<i>courtesy of Massey Brewery</i>)
18:00-18:15	Whakatau/Welcome
18:15-19:00	Opening Speaker: Professor Emeritus Gary Hermansson, Massey University.

Day Two: Thursday 28th November (Sir Geoffrey Peren)

7:30-8:30	Registration and refreshments		
8:30-9:00	Karakia Timatanga/Opening		
9:00-10:00	Keynote Speaker: David Howman , Chair of Athletics Integrity Unit (IAAF), Adjunct Professor, Auckland University of Technology		
10:00-10:30	Morning Tea		
Parallel Sessions	Auditorium (Biomechanics)	1.02 (Physiology)	1.04 (Coaching)
10:30	Do generalized hypermobility and knee hyperextension influence Landing Error Scoring System scores? <i>Ivana Hanzlíková</i>	How do menstrual phase and ambient temperature affect exercise-iron status in females? <i>Huixin (Lizzie) Zheng</i>	Being Part of The Team: A review of caregiver sideline behaviour interventions. <i>Patrick Lander</i>
10:45	The effect of a 16-week foot muscle specific intervention program on non-contact anterior cruciate ligament (ACL) and lateral ankle sprain (LAS) injury risk. <i>Carla van der Merwe</i>	The effectiveness of self- versus externally-controlled heat strain, and the heterogeneity of self-regulated heat strain, in active heat acclimation. <i>Jamie Prout</i>	It's not all about the numbers: How the Silver Ferns used performance analysis to develop their game during the 2019 NWC. <i>Hayden Croft</i>
11:00	Acute potentiating effects of a weighted club warm-up on golf driving performance and biomechanics. <i>George Wardell</i>	The effects of menstrual cycle phase on physical performance in female rugby athletes: A case series study. <i>Francesco Sella</i>	Introducing the Certified Footwear Analyst: A multi-sport applied research project. <i>Codi Ramsey</i>
11:15	A head-to-head comparison of scientific versus practical bike fitting methods. <i>Kim Hébert-Losier</i>	How complex is complex? RED-S research needs a transdisciplinary approach. <i>Katie Schofield</i>	Psychological need satisfaction: Athlete insights into the coaching impact within a high performance team. <i>Warrick Wood</i>
11:30-12:30	Lunch		
12:30-13:30	Keynote Speaker: Associate Professor Jason Lee , National University of Singapore.		
Parallel Sessions	Auditorium (Tactical Athlete)	1.02 (Psychology)	1.04 (Physiology)
13:30	Physical performance monitoring of infantry soldiers during a 24 hour tactical resilience exercise in the New Zealand Army. <i>David Edgar</i>	The Effect of Neurofeedback Training on Walking Performance Under a Constrained Induced Motor Impairment. <i>Amanpreet Sidhu</i>	The Effect of Swilling Carbohydrate, Menthol or a Combination on 40km Cycling Time Trial in the Heat. <i>Kerin McDonald</i>
13:45	Comparison of Post-Exercise Heat Acclimation Methods in a Military Context. <i>Edward Ashworth</i>	The effect of red and blue background on shot selection in an indoor football penalty-shooting task. <i>So Hyun Park</i>	Lifestyle factors as an alternative to immune predictors of upper respiratory tract symptom risk in elite rugby union players. <i>Lauren Keaney</i>

Day Two: Thursday 28th November (Sir Geoffrey Peren)

14:00	New Zealand Defence Force (NZDF) - SESNZ Discussion <i>David Edgar, Peter Franken, Kasey Vissers.</i>	The effects of working memory fatigue on verbal-analytical engagement in motor planning. <i>Merel Hoskens</i>	How hot do muscles get during resistance exercise? <i>Ben Smith</i>
14:15		The role of anxiety on goal shooting performance in elite netball players. <i>Liis Uiga</i>	Characterising the thermal effects of aerobic exercise in skeletal muscle. <i>Thomas de Hamel</i>
14:30-15:00	Invited Speaker: Professor Narihiko Kondo, Kobe University		
15:00-15:30	Afternoon Tea		
Parallel Sessions	Auditorium (High Performance Sport)	1.02 (Physical Activity & Health)	
15:30	The future of the HPSNZ Innovation Programme. <i>Stafford Murray</i>	Muscle-strengthening exercise for general population health: Is it the “forgotten guideline”? <i>Wendy O’Brien</i>	
15:45	Performance Technique Analysis delivery in the High Performance Environment: WHAT, HOW and WHY? <i>Justin Evans</i>	Health Behaviour Survey in a New Zealand Tertiary Institution with a focus on Physical Activity. <i>Richard Humphrey</i>	
16:00	Beating the heat in Tokyo - HPSNZ. <i>Lorenz Kissling</i>	High Intensity Interval Training compared with standard care before major abdominal surgery. <i>Kari Clifford</i>	
16:15	Characterisation of core temperature response to an international rugby sevens tournament played in hot and humid conditions. <i>Stephen Fenemor</i>	Accumulated or continuous exercise for cardiometabolic health. <i>Philip Shambrook</i>	
16:30-17:30	POSTER PRESENTATIONS		
17:30-onwards	Social function at Distinction Coachman Hotel		

Day Three: Friday 29 th November (Sir Geoffrey Peren)		
8:00-8:30	Refreshments	
8.30-9:30	Keynote Speaker: Distinguished Professor Aaron Coutts , University of Technology Sydney.	
Parallel Sessions	Auditorium (Physiology)	1.02 (Strength & Conditioning)
9:30	Running economy and performance in three different running shoes. <i>Steven Finlayson</i>	The reality of small-sided games in rugby union. <i>Koen Wintershoven</i>
9:45	Functional threshold power is an estimate of critical power. <i>Charles Pugh</i>	The effect of upper limbs Thera-Band training on the tennis service speed of adolescent tennis players. <i>Sellathurai Jeganenthiran</i>
10:00	The athlete's vein: Venous adaptations of the lower limb in endurance athletes. <i>Holly Campbell</i>	The Strength and Conditioning Coach: Breaking Free From Signature Pedagogies. <i>Phil Handcock</i>
10:15	The potassium-carbohydrate interaction as a potential mechanism of skeletal muscle fatigue during high-intensity exercise. <i>Simeon Cairns</i>	Working Conditions of Strength and Conditioning Coaches in New Zealand and the Pacific Islands. <i>Bennett Jones</i>
10:30-11:00	Morning Tea	
Parallel Sessions	Auditorium (Nutrition & Metabolism)	1.02 (Sports Medicine and Rehabilitation)
11:00	Exercise and the Microbiota: An Update. <i>Nancy Rehrer</i>	The Effect of Altitude on Concussion in University (American) Football Players. <i>Jennifer Treacy</i>
11:15	The effect of bicarbonate supplementation on plasma acidosis and peak power during a simulated 4000-m individual pursuit on a bicycle ergometer in elite athletes. <i>Mathew Mildenhall</i>	OUCH: responses to a new model of contusion injury. <i>Matthew Barnes</i>
11:30	Comparison of the effects of different forms of caffeine supplementation on 5-km running performance. <i>Carl Paton</i>	Application of the new Samsung S-Patch Electrocardiography Device in an Exercise Based Rehabilitation. <i>Ellie Rickman</i>
11:45	Menthol mouth rinsing does not improve strength or power performance. <i>Russ Best</i>	A crossover comparison of four cardiopulmonary exercise testing modalities in severe lower-limb osteoarthritis patients. <i>B.H. Roxburgh</i>
12:00-13:00	Lunch (AGM)	
13:00-14:00	Keynote Speaker: Dr Andy Cooke , Bangor University.	
14:00	Cerebral blood flow regulation in severe heat stress: Effect of the heat source. <i>Travis Gibbons</i>	
14:15	Using inertial measurement units to determine the potential efficacy of a motor analogy for improving landing from self-initiated falls. <i>Sana Oladi</i>	
14:30	Float tanks for improving athletic recovery: FAD or feasible? <i>Matthew Driller</i>	
14:45-15:15	Poroaki/Closing	



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gbcBioMed is proud to have supported SESNZ over many years and to be the Platinum Sponsor this year.

Thanks, SESNZ, for this opportunity to show its appreciation to our many sports science customers for their support. Platinum Sponsorship includes 4 free registrations so gbcBioMed was especially pleased to be able offer these and see all 4 snapped up.

During our involvement with SESNZ, we have witnessed the changes in the organisation and the conferences - from the combined GP/SESNZ to the current stand-alone conferences!

It's very evident from the last few conferences that SESNZ has found new energy and commitment - we hope this will continue and will inspire unity within the sports science community.

gbcBioMed has been in business for around 15 years and like SESNZ we have evolved over this time – however our business philosophy remains the same – to represent world leading manufacturers, producing the best products which are unique and innovative. gbcBioMed adds to this with our commitment to excellent sales and service support.

Such brands as Cortex, Lode, h/p/cosmos, AccunIQ, Cyclus2, BTS, InBody, Zephyr, Vacu-Med, Hans Rudolph, EGZO Tech and Swift Performance can be found in sport science labs all round the world.

Most NZ sports science labs have equipment that gbcBioMed has supplied and supported, along with private clinics, high performance clinics and hospitals.

Martin Little, our Service Engineer and I have had the privilege of visiting, most of the labs in NZ, some in Aussie and other countries.

Kiwi labs are up there with the best in the world,... anything lacking due to funding restraints etc. is almost made up for with enthusiasm and smart thinking – actually, more funding would work wonders as well!!!

GbcBioMed, like SESNZ, is changing and we are always looking to improve and broaden our product range while sticking to our philosophy. So, if you encounter a company developing a new or innovative product which you think is good, we would love to hear about it. Equally if you have some ideas that can be developed into a product we would be keen to talk.

GbcBioMed has cultivated an extensive world-wide network of contacts so we can usually assist with equipment selection advice, or help with choosing the best option for your next project.

Enjoy the conference; catch up with old friends and make new ones; learn and contribute new ideas.

Ken Marment

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GSI Direct specialise in providing small businesses, consultants and contractors with affordable liability insurance online in New Zealand. We encourage SESNZ members to investigate whether they can save on their premiums through this offering, or if they currently don't purchase any insurance, investigate whether it's something they should consider.

Keynote Speakers

Dr Andy Cooke

Andy is a member of the Institute for the Psychology of Elite Performance at Bangor University. He has a BSc in Sport Science (Bangor University, 2004-2007) and a PhD in Psychophysiology (University of Birmingham, 2007-2010). Andy worked as an ESRC Postdoctoral Research Fellow at the University of Birmingham (2010-2012), before returning to Bangor University as a Lecturer in the School of Sport, Health and Exercise Sciences (2013-Present). His research employs a multi-measure approach (e.g., brain, eyes, heart and muscles) to investigate: a) the psychophysiological mechanisms underpinning human performance; and b) psychophysiological interventions to enhance performance (e.g., neurofeedback training). It covers a range of performance domains including sport (e.g., preparatory cortical activity distinguishes successful from unsuccessful golf putts), health (e.g., effects of neurofeedback on the motor symptoms of Parkinson's disease), and transportation (e.g., effects of gaze-training on driving), and has been supported by a variety of funders (e.g., ESRC, NHS, AXA insurance, England and Wales Cricket Board). Outside of work, Andy enjoys watching and participating in sport, where he tries to employ the performance-optimization techniques that he researches.



Professor Emeritus Gary Hermansson

Gary is one of NZ's top sport psychologists. His background involves playing rugby at a high level (including being in Wellington Teams that beat both the Springboks and the British and Irish Lions), and for a number of years he taught counsellors at Massey University (now holding the status of Emeritus Professor). He moved into sport psychology at its emergence in this country 30 years ago and has been active in that field ever since. He has been the NZ team psychologist at 5 Commonwealth and 5 Olympic Games (from Kuala Lumpur to Rio), for the NZ Black Caps cricket team over 14 tours, for the NZ Equestrian Team at an international World Cup campaign, and he has also worked with dancers at the NZ School of Dance. He is currently contracted to High Performance Sport NZ to work with elite athletes and coaches in a variety of sports, and has written a book entitled 'Going Mental in Sport: Excelling through Mind-Management'. He has also been invested as an Officer of the NZ order of Merit for his contributions to the field of Sport Psychology, and has been made a Holder of the NZ Olympic Order for his services to the Olympic Movement.



David Howman CNZM

David is a barrister in Wellington. He is the Chair of the Athletes Integrity Unit, having been re-appointed to that position by the IAAF Council in September 2019, the Chair of World Squash Ethics Commission, Deputy Chair of the ITF Ethics Commission, and Chair of the ICC Anti-Corruption Oversight Group. David was a member of the Australian Government's Panel reporting on Sport Integrity in 2018, and holds the position of Adjunct Professor at AUT.



David was Director General (more corporately named the CEO) of the World Anti Doping Agency (WADA), from August 2003 until July 2016, and was instrumental in the shaping of WADA into a highly respected and unified global organization responsible for regulating and monitoring world sport and world governments. Among many partnerships developed by WADA during this time was one with Interpol cemented by a MOU signed in 2009.

With a large experience of governance at both local and national levels in sport in New Zealand, accompanying his management skills, David brings a unique leadership capacity to all matters he is engaged in.

David received a CNZM for services to sport in 2017.

Distinguished Professor Aaron Coutts PhD

Aaron is a Distinguished Professor and Director of the Human Performance Research Centre at the University of Technology Sydney (UTS). For the past 20 years Aaron's research has centred towards developing evidence-based methods for improving performance and health of athletes. During this period, he has published more than 200 scientific articles. Much of Aaron's applied work has focused on developing systems to monitor and control the training process in high performance athletes. Further to his academic work, Aaron provides sport science advice to several leading national and international sporting organisations. Aaron is also the Director of Exercise and Sport Science Australia (ESSA) and a member of the Nike Sport Research Laboratory International Advisory Board. He is an Associate Editor for the International Journal of Sports Physiology and Performance and Science and Medicine in Football.



Associate Professor Jason Lee Ph.D., FACSM

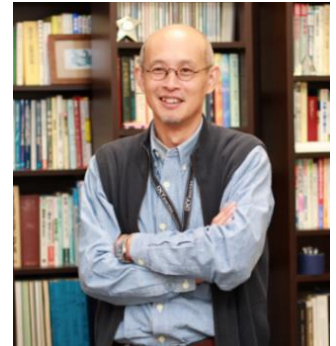
Jason is a Research Associate Professor from the School of Medicine, National University of Singapore. Jason obtained his first degree (Sports and Exercise Science – 1st Class Honours) from Loughborough University, UK. Following the award of G V Sibley Memorial Prize, he stayed on to complete a PhD in Exercise Physiology under sponsorship from the UK Overseas Research Scholarship and Faculty Studentship. Jason is a Fellow of the American College of Sports Medicine. Tapping on his experience as a commando Officer in the Singapore Armed Forces and domain knowledge, he serves in various national and international panels related to human performance and safety. Jason recently completed his 12-year tenure at the DSO National Laboratories by directing the Human Performance Programme in his final appointment. He chairs the Thermal Factors



Scientific Committee, International Commission on Occupational Health. He is a member of the WHO-WMO Workgroup Report on Climate Change on Workers.

Professor Narihiko Kondo

Narihiko Kondo is a Professor in the Graduate School of Human Development and Environment, Kobe University. He graduated from the Graduate School of Physical Education in Tsukuba University, 1989 with his PhD. He focuses on the integrated control of sweating and skin blood flow during exercise and is interested in the effect of aging, gender, physical training (heat acclimation), and mental stress on both autonomic and behavioural thermoregulation.



Keynote Presentations

In the Company of Champions: Pathways in the Wilderness

Gary Hermansson, Professor Emeritus¹

¹ *Massey University*

Gary Hermansson has had a notable presence in the field of applied sport psychology in New Zealand since its emergence in this country over 30 years ago. Over that period, he has worked with a wide range of high performance athletes and coaches in a variety of sports as well as with individuals in the performing arts. In this presentation, he will share experiences and insights arising from such involvements and in doing so will look to illuminate emerging pathways in this still relatively nascent field.

Where to now for Sport Integrity; Globally and here in New Zealand?

David Howman, CNZM¹

¹ *Chair of the Board of Directors at Athletics Integrity Unit (IAAF)*

This talk will cover what has been done internationally by the IAAF, and by the Australian Government, along with other advances including an update here in New Zealand. The talk will also include examples of the big issues I have had to deal with both at the World Anti-Doping Agency and more recently in my other roles.

Application of thermal physiology in a warming world

Jason K.W. Lee^{1,2,3}

¹ *Department of Physiology, YLLSoM, National University of Singapore, Singapore*

² *Global Asia Institute, National University of Singapore, Singapore*

³ *N.1 Institute for Health, National University of Singapore, Singapore.*

The debilitating effect of heat stress are well known. Excessive hyperthermia can impair exercise performance and capacity. Exercise tolerance in the heat is affected by multiple factors such as the attainment of a high heat strain, cardiovascular insufficiency, metabolic disturbances and reductions in central nervous system drive to skeletal muscle. In order to optimize exercise tolerance in the heat, various methods have been proposed - aerobic fitness, heat acclimatisation, pre-exercise cooling and fluid ingestion. These strategies have shown to be effective in prolonging exercise tolerance in warm conditions through various processes that include alterations in heat dissipation ability, cardiovascular stability and adaptations, and changes to the body's heat storage capacity. New attention on this issue has been created by the ongoing climate change, which in large parts of the world has induced more hot days each year

and hotter hot days, made worse with urbanization. Physiology is becoming a core discipline for climate change health impact assessment. I will share my personal journey and scientific insights gained through sports science, the application and unique considerations when applying the discipline in the military context where I spent 12 years as a defence scientist, and extending physiology to heat health in public settings.

Developing Integrated Athlete Monitoring and Decision Support Systems for High Performance Sport

Aaron Coutts, PhD¹

¹ *Human Performance Research Centre (Director), Sport and Exercise Science, University of Technology Sydney, Sydney, Australia*

The primary goal of athlete monitoring is to provide information that can be used to inform coach decision-making and improve the training process. If designed and implemented effectively, these systems can aid athletes by reducing training errors, increasing athlete training availability and improving athletic performance. In this presentation, we will examine the theoretical basis for athlete monitoring and provide a conceptual framework to inform the development of these systems. We will examine the fundamental components of these systems (i.e. the load and athlete response measures) and critically examine the evidence supporting each. We will also assess the evidence that examine the effectiveness of these systems for assessing injury risk and/or performance readiness. Finally, we explore how these measures can be integrated into athlete decision support systems and provide recommendations for optimising these processes.

Use your brain! Brainwaves predict behaviour, how can they be trained?

Andy Cooke, PhD¹

¹ *School of Sport & Exercise Science, Institute for the Psychology of Elite Performance, Bangor University, Bangor, Wales*

What determines optimal motor performance? One way to address this question involves the measurement of brain activity during motor performance, using electroencephalography (EEG). Research adopting this approach has revealed that alpha waves (brainwaves that oscillate at a frequency of 8-12 Hz and are involved with neuronal inhibition) may play a key role. In the first part of this talk I will present EEG alpha data from sport to identify patterns of alpha brainwaves associated with optimal performance. This research sheds light on the mechanisms underpinning motor proficiency. In the second part of this talk, I will present some recent applied work aimed at teaching

individuals to recreate the brainwaves that characterize optimal performance at will. Using a form of brain training called neurofeedback, golfers were able to volitionally shape their brainwaves during their pre-putt routine, while untrained cyclists were able to boost their time to exhaustion by 30%. I will also

share data on the effects of neurofeedback outside of sport, where it may serve as a non-pharmacological adjunct treatment for the motor symptoms of Parkinson's disease. The implications of these findings, and recommendations for future brain-based sport and exercise research, will be discussed.

Invited Presentations

Heat loss responses in athletes

Professor Narihiko Kondo¹

¹ *Laboratory for Applied Human Physiology, Graduate School of Human Development and Environment, Kobe University, Kobe, Japan*

Humans have developed such a remarkable system for endurance exercise in the heat, that we could outrun almost all other mammals, including horses. The key for maintaining exercise in the heat may reside in controlling both core body temperature and systemic blood pressure simultaneously. Thus, thermoregulatory research, especially during exercise in the heat, are critical to understanding human adaptation to tropical conditions. During exercise, heat loss (via sweating and skin blood flow) is regulated by two main factors; thermal (core and

skin temperature) and work factors (non-thermal; central command, muscle metabo-/mechano-receptors etc.). In addition, these heat loss responses are improved by exercise training. The magnitude of improvement to these responses is associated with 1) the level of maximal oxygen uptake (VO₂max), 2) the degree of body temperature elevation, and 3) the degree of activation of heat loss responses during exercise training. There are many types of exercise training for improving sports performance and these various types of training may induce differential adaptations in thermoregulatory responses. For example, sprinters and distance runners exhibit different sweating responses. I will present an integrative control of heat loss responses during exercise and then the effect of different types of exercise training on these responses.

Oral Presentations

Biomechanics

1. Do generalized hypermobility and knee hypermobility influence Landing Error Scoring System scores?

Hanzlíková, I.¹, Hébert-Losier, K.¹

¹University of Waikato

Introduction: The Landing Error Scoring System (LESS) is a reliable and valid injury risk screening tool used to identify potentially high injury risk movement patterns. These patterns may be altered in participants with hypermobility or knee hyperextension. **Method:** Eighty-five young active individuals (37 females, 48 males) were tested using LESS and Beighton hypermobility tests. Spearman rank correlation coefficient was calculated to investigate relationship between LESS and Beighton scores. Furthermore, a *t*-test was performed to explore differences in LESS scores between non-hypermobility and hypermobility participants, as well as between participants with passive knee extension < 10° and passive knee extension ≥ 10°. **Results:** The mean LESS score was 5.4 ± 1.4 errors and median (interquartile range) Beighton score was 2 (4) points. No significant relationship was found between LESS and Beighton scores (*p* = -0.08, *p* = 0.490). The LESS scores between non-hypermobility (5.2 ± 1.5 errors) and hypermobility (5.5 ± 1.3 errors) participants and between participants with knee extension < 10° (5.6 ± 1.5 errors) and knee extension ≥ 10° (5.3 ± 1.4 errors) were comparable (*p* > 0.05). **Discussion:** Generalized hypermobility and knee hyperextension do not influence LESS scores. **Take home message:** Despite LESS scores, Beighton scores, and knee hyperextension being identified risk factors for non-contact anterior cruciate ligament injuries in the scientific literature; the latter two aspects did not influence LESS, indicating that these tests assess different constructs and injury risk factors.

2. The effect of a 16-week foot muscle specific intervention program on non-contact anterior cruciate ligament (ACL) and lateral ankle sprain (LAS) injury risk

van der Merwe, C.¹, Shultz, S.P.², Colborne, B.G.R.³, Hébert-Losier, K.⁴, Fink, P.W.¹

¹School of Sport, Exercise and Nutrition, Massey University, Palmerston North, New Zealand

²Department of Kinesiology, University of Seattle, Seattle, WA, United States of America

³School of Veterinary Science, Massey University, Palmerston North, New Zealand

⁴The University of Waikato, Faculty of Health, Sport and Human Performance, Adams Centre for High Performance, Tauranga, New Zealand

Introduction: ACL injury risk increase when excessive subtalar joint pronation (medial longitudinal arch (MLA) height), coupled with internal tibial rotation creates large knee valgus angles under extreme loads. Forefoot (metatarsal anterior transverse arch (MetATA)) instability, linked to larger ankle moment arms increases LAS injury risk. We investigated the effect of a foot-muscle specific intervention on ACL and LAS injury risk factors. **Methods:** Eighteen skilled female court sport athletes were matched (sport and BMI) and randomized to the training (TG) or control group (CG). Athletes performed unanticipated, 45° changes of direction barefoot at speed. 3D motion (multi-segmental foot model) and force data was collected from the dominant lower limb. The TG underwent a progressive 16-week foot muscle specific exercise program. R² goodness-of-fit and ANOVA analysis tested pre-to-post-intervention adaptations within and between groups respectively. **Results:** TG R² MLA height values were larger (*p* < 0.05), MetATA height values larger (*p* = 0.08) and length smaller (*p* = 0.18). TG maximum knee valgus angle decreased (*p* = 0.20), ankle inversion angle had a smaller increase (*p* = 0.11) and ankle eversion moment arm length had a larger decrease (*p* = 0.13). **Discussion:** The TG had dynamically stiffer arches compared to the CG, possibly decreasing some ACL and LAS injury risk factors. Training the foot muscles increased arch stiffness, possibly influencing the frontal plane knee and ankle biomechanics, decreasing some ACL and LAS injury risk factors. **Take home message:** A 16-week progressive foot muscle specific intervention changed foot function and decreased some ACL and LAS injury risk factors.

3. Acute potentiating effects of a weighted club warm-up on golf driving performance and biomechanics

Wardell, G.L.¹, Hébert-Losier, K.¹

¹University of Waikato

Introduction: Various warm-up strategies are used to induce post activation potentiation in golf to enhance clubhead velocity. We investigated the effect of the SuperSpeed weighted club warm-up protocol on golf performance and swing biomechanics. **Methods:** 3D motion analysis (500 Hz) was used to investigate swing biomechanics of 12 golfers (handicap < 3.0) in a cohort study design comparing a golf-specific control warm-up to the SuperSpeed warm-up. Swing, X-factor, peak angular velocity, and centre of mass (COM) parameters were compared between conditions using Cohen's standardised effect size (ES). **Results:** Clubhead velocity; angular velocity of the torso, lead arm, and club; and COM at the top of backswing in the target direction (*x*) and in the posterior direction (left of the target, *y*) at impact showed a significant (*p*

< 0.05) small ($ES > 0.2$) and likely (greater than 75% likelihood) change after use of the SuperSpeed warm-up. However, despite an increase in clubhead velocity, there were no meaningful changes in ball velocity, resulting in a negative change in the smash factor ($ES -0.80$, $p = 0.008$). **Discussion:** Using the SuperSpeed warm-up significantly influenced COM and peak angular velocities, increasing clubhead velocity by 2.6 mph. No significant changes were seen in X-factor variables despite previous research associating X-factor with clubhead velocities. **Take home message:** Although the SuperSpeed warm-up protocol significantly increased clubhead velocities, ball velocities were not improved. The lack of transference from clubhead to ball velocities is likely due to the lack of familiarity with the novel biomechanical patterns.

4. A head-to-head comparison of scientific versus practical bike fitting methods

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Introduction: Bike-fit technicians typically optimise bike fit using experience, look-and-feel, and 2D video analyses rather than 3D methods or scientific evidence. Therefore, bike technicians and scientists have different measures and views on optimal bike configurations. Saddle height remains one of the most vital bike-fit aspects with implications for performance and injury management. **Methods:** Saddle heights and bike-fit measures used to set saddle heights were recorded from 11 recreational road cyclists (8 males, 3 females) based on Hamley & Thomas, trochanteric, ischial tuberosity, and LeMond methods. Cycling motion was recorded at 120 Hz in 3D (Qualisys AB) and 2D (Sony RX10 II) to compare kinematics from 90-s 150 W efforts completed on a Cyclus 2 ergometer using participants' own bikes. Results: On average, the absolute difference between measured and recommended saddle heights across methods was 3.4 ± 2.0 cm. Measured heights most aligned with the LeMond method and the least with the ischial tuberosity method. All 2D angles significantly differed from 3D. Shoulder-joint angles were the most comparable between 2D and 3D.

Physiology, Strength and Conditioning

5. How do menstrual phase and ambient temperature affect exercise-iron status in females?

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Introduction: Iron deficiency is prevalent among eumenorrheic females and endurance athletes. However, no study has determined whether a female athlete's post-exercise iron status is affected by her menstrual phase or ambient environment. **Methods:** Eight moderately trained and eumenorrhoeic females (age, 37 ± 7 y; $\dot{V}O_{2\max}$, 46 ± 7 ml·min⁻¹·kg⁻¹) completed four experimental trials: 20.5 ± 0.6 °C (MOD) and 31.7 ± 0.2 °C (HOT), in their early-follicular (EF, day 5 ± 2) and mid-luteal (ML, day 21 ± 3) phase, respectively. Each trial consisted of 20 min fixed-intensity cycling followed by a 30 min self-paced time-trial. Venous blood was taken before and after exercise to determine iron status. **Results:** Increased [progesterone] (by 10 ng·ml⁻¹, $P < 0.05$) and resting rectal temperature (T_{rec} , by 0.3 °C, $P = 0.02$) verified desired menstrual phases. ΔT_{rec} (by 0.3 °C) and mean heart rate (by 9 beats·min⁻¹) were greater in HOT (both $P < 0.05$) than MOD for both EF and ML. Work completed was 3% lower during the time-trial in HOT ($P = 0.02$). Baseline haemoglobin, ferritin and transferrin concentrations were not different between phases (all $P > 0.3$) and increased following exercise (all trials $P < 0.05$). **Discussion:** From these results, we can conclude that in moderately trained, non-iron deficient females, heat stress impairs exercise performance. However, changes to post-exercise iron status is not affected by their menstrual phase or ambient temperature. **Take home message:** Regarding a one-off bout of exercise, ambient temperature and menstrual phase will not affect females' post-exercise iron status.

6. The effectiveness of self- versus externally-controlled heat strain, and the heterogeneity of self-regulated heat strain, in active heat acclimation

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Introduction: Humans adapt effectively to heat. Clamped hyperthermia (core temperature [T_c] +1.5 °C) is deemed the 'gold standard' approach to heat acclimation [HA], however, people typically self-regulate their exposure. The purpose of this study was to determine the effectiveness of clamped vs. self-regulated HA, the heterogeneity of self-regulated heat strain, and whether this heterogeneity associated with the extent of adaptation. **Method:** Eight endurance-trained participants (24 ± 6 y; 2 female) completed two cross-over HA regimens, 6-wk apart; one clamped [CLAMP], and one self-regulated [SELF] with no feedback on T_c . Both regimens involved 9-d cycling-based HA (60 min·d⁻¹) in humid heat [40 °C, 50% RH]. A fixed-intensity heat stress test (1.75 W·kg⁻¹ for 30 min) was conducted on days 1, 5, and 9. **Results:** HA successfully induced classic adaptations ($p = 0.01$ to 0.1), which tended to be greater in SELF for exercising heart rate and sweat rate (both $p = 0.07$). 7/8 participants preferred SELF. In SELF, heterogeneity was marked between participants (daily T_c gain = 1.1 to 2.2 °C) but not across nine days ($p = 0.43$). No association was evident between daily T_c strain and adaptations in T_c , plasma volume, or exercising heart rate ($r^2 = 0.01$ to 0.06).

Take home message: SELF was as effective as CLAMP in eliciting standard markers of HA. Large inter-individual differences were evident but people who got hotter in SELF did not necessarily adapt more. Therefore, we preliminarily recommend self-regulated HA for athletes, whereas researchers could use whichever suits their question(s).

7. The effects of menstrual cycle phase on physical performance in female rugby athletes: A case series study

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Introduction: Limited research exists on the effects of menstrual phase on athletic performance in team sport athletes. This study aimed to investigate the effect of menstrual cycle phase on a number of physical qualities in rugby athletes. **Methods:** Six eumenorrhoeic female rugby athletes completed a battery of physical tests weekly for 5-9 weeks, including 10-m sprint, countermovement and drop jumps, Bronco, and isometric leg strength. Concurrently, athletes tracked their menstrual cycle with a smartphone application (FitrWoman™). To investigate differences in physical performance between phases, data were allocated into follicular or luteal phase at the date of each weekly test. A linear mixed model was created for each physical quality of interest (e.g., speed, jumping ability, fitness, strength). Specifically, menstrual cycle phase was entered as fixed factor, whereas athlete was included as random effect. P-values were calculated using ANOVA with significance set at $p \leq 0.05$. Individual and between-subjects average testing scores for each phase were also computed and compared using effect size (ES) and magnitude-based approaches with 90% confidence intervals. **Results:** No significant differences were observed between phases. However, when comparing average scores, the luteal phase demonstrated possibly greater Bronco performance compared to follicular (ES = 0.34). In addition, one athlete displayed likely to very likely faster 5 and 10-m sprint times in the luteal phase (ES = 0.57 and 0.83). **Take home message:** Understanding and accounting for individual responses during the menstrual cycle will likely be beneficial to training prescription and interpreting performance monitoring results.

8. How complex is complex? RED-S research needs a transdisciplinary approach

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Introduction: Low energy availability (LEA); when dietary intake, after exercise, does not meet the demands of normal physiological functioning, is the underlying aetiology of relative energy deficiency in sport (RED-S). RED-S is a highly complex syndrome however, current RED-S research typically operates in two distinct disciplines—the physiological and the socio-psychological—with most literature focused on the former. To understand the complexities of this syndrome a transdisciplinary research approach will be discussed. **Method:** Using a case-study of a female track cyclist, a novel transdisciplinary approach will be highlighted within the context of RED-S. Measures of physiological (energy availability, bone mineral density, resting metabolic rate, reproductive hormone status) and socio-psychological (semi-structured interviews) will be presented. **Results:** The athlete had LEA despite current physiological measures being in the normal range. From a semi-structured interview, the athlete shares her experience of menstrual irregularities, body image pressures and the high-performance environment that are probable causes to her LEA state. Implementing a transdisciplinary research approach has many advantages (e.g. collaboration, create new knowledge) and challenges (e.g. time and resource intensive). The outcomes of a transdisciplinary research approach uncover nuances and knowledge that is often missed in the siloed approach towards understanding RED-S in athletic populations. **Discussion:** Each category rightly has their place in the literature and have contributed to the singular aspects of RED-S research. However, RED-S is incredibly complex and integrated there is a need for transdisciplinary research to fully understand the complexities of this syndrome in athletes. **Take home message:** RED-S is a highly complex syndrome but, future RED-S research needs to move away from siloed approaches. Therefore, to gain a greater understanding, it is proposed that research methods are conducted in an integrative, transdisciplinary, holistic manner.

Coaching

9. Being Part of The Team: A review of caregiver sideline behaviour interventions.

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Introduction: Sideline misbehaviour is commonly cited as a concern at children's sport across Aotearoa. The aim of this review was to identify literature investigating factors affecting caregiver behaviour whilst observing children's sport. **Method:** Four databases were searched for articles up to June 2019. Peer reviewed studies were eligible for inclusion if they reported adult caregiver behaviour while watching children's sport. Studies were coded and analysed using NVivo qualitative data analysis software. **Results:** Findings addressed specific elements of misbehaviour or provided guidance for caregivers to understand how their actions influenced children playing sport. Literature suggested that the need to educate parents was seen as important to children, coaches, referees, and parents. The size of the problem caused by poor behaviour was unclear. **Discussion:** Poor caregiver sideline behaviour has a clear negative impact on children's participation in sport. The impact of the behaviour of the positive majority may be lost by seeking out the impact of the negative minority. Few studies have considered behaviour beyond the sideline to look at caregiver influence when travelling to and from children's sport. **Take home message:** Balanced education programmes that enable caregivers to better understand the impact of behaviour on and off the sideline are to be encouraged. Research into effective tools to observe the impact of caregiver (mis) behaviour, and to determine the size of the problem is required.

10. It's not all about the numbers: How the Silver Ferns used performance analysis to develop their game during the 2019 NWC

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Introduction: The nature of the Netball World Club (NWC) tournament required continuous adaptations to performance analysis delivery. Findings in an elite rugby setting informed some elements of the practice-based approach but ultimately, a novel delivery style was developed. This case presentation reflects on the processes that the Silver Ferns netball team used to progress team strategy, structures and opposition scouting within a performance analysis framework. **Method:** Three stages of reflective practice were used; (1) problem definition, (2) analysis, and (3) generalisation to reflect on the strategies used and the lessons learned during the NWC. **Results:** Time constraints during the NWC increased the cognitive demands from the Silver Fern Players. To reduce confusion and maintain

role clarity the coaching team narrowed the focus of player feedback to mainly include the structures and actions of on-court performances as viewed through video reflection. Minimal opposition scouting allowed an inward focus on the team and individuals. Team meetings were a prominent feature of the analysis process however individual reflection was also implemented for position specific role clarity. Statistical measures of individual performance indicators (PI) were captured but were used sparingly. Instead, team measures were used almost exclusively. **Discussion:** The combination of players and coaching staff allowed analysis and game preparation to be tailored to the constraints of the tournament. While this strategy was successful for this team in this particular setting generalisation is difficult. **Take home message:** An adaptable performance analysis approach is useful and can be applied to any sports team but caution is warranted as the tournament, coaching philosophy, and players must be considered in the approach.

11. Introducing the Certified Footwear Analyst: A multi-sport applied research project

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Introduction: Footwear is often criticised as a causal factor for sport-related injury and performance deficit. Until recently, objective footwear assessments have been absent from research and practice. Regular assessments of footwear from certified analysts are required to provide valid and reliable criteria concerning objective footwear measurements. **Method:** Pilot testing of a project-based learning activity was evaluated. Following a training course on the Certified Footwear Analyst – Total Asymmetry Score footwear assessment tool, Intraclass Correlation Coefficients (ICC) were obtained for 12 post-graduate student's footwear measurements. Kinetic (GRF) data was collected for six of the students using a floor mounted force plate. **Results:** Reliability data for all student's footwear measurements were moderate to excellent (ICC = 0.78 - 0.93). Movement data yielded non-significant effects of footwear (compared to barefoot) on countermovement jump performance ($p=0.36$) and a 45 degree cutting movement ($p=0.15$). Student feedback supported the project with modifications. **Discussion:** This pilot study provided the baseline data for developing a multi-sport project-based learning tool to be carried out at ISEH during 2020. Post-graduate students will be certified as footwear analysts and will measure and assess footwear characteristics, performance and injury over three sport seasons: netball, basketball and cross country. While gold-standard equipment is desired for research purposes, it is often not accessible to industry-level practitioners (i.e. sport coaches). Therefore, in this project, individual movement data will be captured using wearable technology (Vicon-IMU & Athos

EMG clothing) in a lab/classroom-based setting at multiple time-points throughout each sport season. **Take home message:** Implementing a certified footwear analysis method into applied project-based learning environment allows students to gain required skills to critically assess the effects of footwear on athlete's injury and performance.

12. Psychological need satisfaction: Athlete insights into the coaching impact within a high performance team

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Introduction: Basic psychological needs theory has been used extensively within the literature as a framework to explore such areas as motivation and wellbeing. The purpose of this study was to understand athletes' interpretations of how their coaches contributed to each basic psychological need within a high performance sport environment. **Method:** A longitudinal-type

case study of a female sports team was conducted involving semi-structured interviews and observations of formal team activities over the course of seven months. Interview data were approached through an interpretative phenomenological analysis perspective. **Results:** Results confirmed earlier findings that coaches do play a key role in athlete need satisfaction/lack of satisfaction. A range of coaching behaviours were described by participants as being need-supportive and need-neglecting with behaviours likely affecting multiple needs. **Discussion:** The varied perceptions highlighted the complexity of the coaching role, particularly when working with a team that encompasses unique, and, at times, contrasting coaching preferences. Furthermore, the findings extend the relevant literature that has, to date, focused mostly on the provision of autonomy-support. **Take home message:** It was not the coaching behaviours *per se* that affected need satisfaction/lack of satisfaction, but rather it was the experiential state that resulted from the athletes' perceptions that appeared to be most central in determining the athletes' experiences.

Tactical Athlete

13. Physical performance monitoring of infantry soldiers during a 24 hour tactical resilience exercise in the New Zealand Army.

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Introduction: NZDF Resilience training is a means to develop operational personnel with capacity to recover quickly from adversity, maintain durability and operational-readiness under challenging circumstances. Tactical resilience training is undertaken in NZDF, but personnel are often poorly monitored and activities marginally quantified. **Methods:** 16 soldiers from NZ Army had hydration (urine specific gravity), RPE 1-10, Gymaware counter movement jump squat power (watts) & speed (m/sec), GPS distance (km) and body weight (kg) monitored during 24-hours of tactical-resilience training. **Results:** The first 12hrs showed a significant decrease in average body weight (92.9 ± 6 to 88.6 ± 5 , $p < 0.001$), and a significant increase in RPE 1-10 (1 ± 1 to 5 ± 1 , $p < 0.001$). Average speed (m/sec) and hydration decreased (2.91 ± 1.2 to 2.83 ± 1.5 , $p = 0.02$) and ($1.018 \pm .02$ to $1.027 \pm .02$, $p > 0.05$), respectively. Power (watts) was maintained (6302 ± 1000 to 6218 ± 900 , $p > 0.05$). Over the last 12hrs with real-time feedback, monitoring showed a significant increase in hydration (urine specific gravity) ($1.027 \pm .01$ to 1.013 ± 0.2 , $p = 0.03$), power (watts) (6218 ± 1200 to 10147 ± 1300 , $p < 0.001$), and speed (m/sec) (2.83 ± 1.1 to 3.12 ± 1.3 , $p = 0.02$). Body weight (kg) and RPE (1-10) maintained at ($88.6 \text{ kg} \pm 2 \text{ kg}$, $p > 0.05$), and (5 ± 1 , $p > 0.05$) respectively. 42km were covered in 24hr, well in excess of the predicted 18km. **Discussion:** Monitoring and real-time feedback supports maintenance of normal performance and elicits normal power/speed after

extended periods of physical-activity and load-carriage. **Take Home Message:** It is important to monitor military personal during tactical activities to prevent injury or over-stressing soldiers to ensure they can maintain operational-ability.

14. Comparison of Post-Exercise Heat Acclimation Methods in a Military Context

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¹Auckland University of Technology

²University of Otago

Introduction: Heat acclimation (HA) could potentially improve soldier performance and safety when operating in the heat¹. Passive HA has recently been suggested as a feasible method of adapting to the heat,² but further research comparing modes of HA is required. **Method:** 13 males ($\dot{V}O_{2\text{peak}} = 52 \text{ mL} \cdot \text{min}^{-1} \cdot \text{kg}^{-1}$) completed two passive, post-exercise HA regimes in a cross-over design, separated by a 6-week washout. Each involved 5 days of 40 minutes of exercise at the first ventilatory threshold, followed by up to 40 minutes of sauna (70°C , 18% RH) or hot-water immersion (HWI) (39.8°C). Heat-stress tests were conducted pre- and 3 days post-HA involving walking to volitional exhaustion in the heat (33°C , 75% RH) in military clothing while carrying a 20 kg load. **Results:** Improved time to exhaustion, reduced heart rate and increased sweat rate was observed following HA using sauna (by $3.4 \pm 4.5 \text{ min}$, $-8 \pm 7 \text{ bpm}$, $0.058 \pm 0.11 \text{ L} \cdot \text{h}^{-1}$; $p < 0.05$) and HWI (by $2.3 \pm 3.4 \text{ min}$, $-8 \pm 10 \text{ bpm}$, $0.10 \pm 0.16 \text{ L} \cdot \text{h}^{-1}$; $p < 0.05$). Compared to baseline, core temperature reduced following HWI (-0.16°C , $p = 0.015$), but not sauna HA (-0.15°C , $p = 0.133$). Despite this, no significant differences between modalities existed over the course of HA for any variable ($p = 0.624$).

Discussion: Both sauna and HWI HA regimes caused desirable adaptations, of typical magnitude for this volume of acclimation, with no differences in physiology or performance between modalities. **Take home message:** HWI and sauna HA achieve similar adaptations, and either can be used depending on available facilities and preference.

15. New Zealand Defence Force (NZDF) - SESNZ Discussion

Captain David Edgar¹

¹New Zealand Army, JSCC Health, Performance Health Team

Captain David Edgar (Army) is the Human Performance Exercise Scientist for the New Zealand Defence Force, and is also the SME for Strength & Conditioning / Performance Science with the Performance Health Team.

David's current focus of work with NZDF is Enhanced Physical Performance, through a 'High Performance Mind-set', to improved general fitness and physical performance and reduce injury rates of NZDF personnel. The performance health team have also been implementing a number of initiatives over the last couple of years to improve health, reduce injury, mentor PTIs and work closely with commanders to ensure new performance strategies are scientifically advanced and based on practice based learning. David holds a Master's Degree and is currently working toward his PhD in the area of Enhanced Physical Performance and Recovery in the New Zealand Defence Force.

Group Captain Peter Franken¹

¹Royal New Zealand Airforce, Joint Support Component Commander

The Joint Support Component Commander (JSCC) is responsible for delivering NZDF joint support functions that include Defence Health, NZDF Military Police, Joint National Support Element, NZ Defence Support Unit (South East Asia), operational support contracts for Freight and the Joint Movements project.

The Joint Support Component Command unifies the direction of NZDF joint support enablers and focusses on operations, readiness and deployable capabilities; bringing together the critical joint support enabling functions from across the NZDF to deliver support to Operations.

Lieutenant Commander Kasey Vissers¹

¹ Royal New Zealand Navy, Executive Officer Health, Joint Support Component Command

Lieutenant Commander Vissers' current role is as the Executive Officer Health, Joint Support Component Command. As a newly established role, it would be described as an agile and innovative position that conceptualises, develops and implements initiatives and tasks to promote and meet the joint requirements.

Psychology

16. The effect of neurofeedback training on walking performance under a constrained induced motor impairment

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Introduction: Our experiment investigated the effects of electroencephalographic (EEG) based neurofeedback training on dual task walking performance under a constraint induced motor impairment condition. **Method:** Twenty-five participants were instrumented with a leg brace and attended three separate laboratory visits, which each included a pre-test, thirty minutes of neurofeedback training and a post-test. Participants were exposed to all three neurofeedback conditions (decrease EEG high-alpha power by 30%, increase EEG high-alpha power by 30% and sham, in which participants received a tone not based on their real time brain activity). We collected measures of cortical activity (EEG), gait speed under both single (timed up and go test) and dual task (timed up and go test + serial sevens task) conditions, the percentage of serial sevens errors during the dual task phase and the number of times individuals stood up during the neurofeedback training session. **Results:** The results revealed that shortly after receiving 30

minutes of decreased neurofeedback training, a statistically significant improvement in time to completion scores for both single and dual task loads from pre-test to post-test ($p < 0.05$) was achieved; additionally, participants were seen to produce significant improvements in percentage of serial sevens errors from pre-test to post-test ($p < 0.05$). **Discussion:** Participants learned to regulate their brain activity before the acquisition of walking and our results are the first to demonstrate that under a constraint induced motor impairment condition, reducing high-alpha power through neurofeedback training can allow conscious dependent motor activities to become automatic and remain autonomous. **Take home message:** Neurofeedback training could provide a non-pharmacological means to restore normal activation to automaticity-related brain circuits and reduce the need to consciously control movements.

17. The effect of red and blue background on shot selection in an indoor football penalty-shooting task

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Introduction: Colour research in sports suggests that competing against an opponent in red leads to poorer performance outcomes. The colour red is associated with dominance and threat, which can cause avoidance behaviour by the viewer. Thus, the current study aimed to investigate whether viewing a red background compared to a blue background during football penalty-shootouts would promote avoidance motivation reflected by choosing the easier option (i.e., kicking to the larger side of the goal). **Methods:** We adopted an off-center goalkeeper paradigm to create a larger side (i.e., easier option) and a smaller side (harder option). The goalkeeper was positioned marginally off-center (1%, 2%) and obviously off-center (10%, 15%). Kickers had an opportunity to score more points by kicking to the smaller side in the latter condition only. Experienced ($N = 22$) and less experienced ($N = 17$) football players completed two blocks of kicks either against a red spectators or a blue spectators background. **Results:** The results revealed that an effect of colour was present for less experienced players ($p = 0.028$) but not for experienced players ($p = 0.182$), regardless of whether the goalkeeper was marginally or obviously off-center. Specifically, less experienced football players chose the easier option more often when seeing a blue background (17.71 ± 4.461) than a red background (12.50 ± 3.629). **Discussion:** Unlike previous research, our findings suggest that blue not red evokes avoidance motivation, but only in less experienced football players.

18. The effects of working memory fatigue on verbal-analytical engagement in motor planning

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Introduction: Implicit motor learning paradigms aim to minimise verbal-analytical engagement in execution of the motor skill by reducing working memory activity during practice. Consequently, skill execution becomes less attention demanding. Here we test whether fatiguing working memory reduces verbal-analytical engagement during practice. **Methods:** Fifty-nine participants were randomly allocated to a fatigue or control intervention. The fatigue intervention, a cognitively demanding motor task, was designed to over-work memory functions involved in motor processing. The control intervention was a non-cognitively demanding motor task. Feeling of fatigue and working memory performance were determined pre- and post-intervention. Thereafter, three blocks of 20 practice trials of a complex shuffleboard task were completed. Verbal-analytical engagement in motor planning was assessed by analysing electroencephalography connectivity between the verbal-analytical temporal region (T7) and the motor planning region (Fz) of the brain for the 3 seconds preceding movement initiation. **Results:** Participants reported higher levels of mental fatigue and displayed reduced working

memory performance following the fatigue protocol. Furthermore, significantly greater T7-Fz connectivity was apparent prior to movement initiation in the fatigue condition compared to the control condition. **Discussion:** Working memory fatigue was achieved in this study; however, verbal-analytical engagement in motor planning increased rather than decreased. **Take home message:** We conclude that working memory fatigue caused reduced motor efficiency, which prompted greater verbal-analytical engagement in skill execution.

19. The role of situational demands and anxiety on goal shooting performance in elite netball players

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Introduction: Limited research has been performed in netball examining the anxiety-performance relationship among elite players. In two studies, we investigated the effects of situational demands and anxiety on goal shooting performance in elite netball athletes. **Method and Results:** In study 1, we analysed shooting success at different score-lines during match-play in 15 of the best netball shooters from the 2018 national premiership competition in New Zealand. We found that shooting accuracy fluctuated throughout the game with the most successful shots taken when the team was 3-4 goals ahead and 1-2 goals behind and the least accurate shots taken when the team was 1-2 goals ahead and >6 goals behind. In study 2, we further examined the effects of anxiety on goal shooting performance using a more controlled environment. We asked eleven elite netball shooters to complete 100 shots at goal under high-pressure with and without defender and low-pressure with and without defender conditions. We found no effect of state anxiety on shooting performance; however, we did find that trait anxiety predicted performance under low but not high-pressure conditions, irrespective of the presence of the defender. **Take home message:** The results of these studies suggest that performance fluctuates throughout the game, which might be associated with levels of anxiety experienced by different players at different score-lines. Individual differences in trait anxiety might explain how players cope with the increased anxiety in order to maintain high performance levels under demanding conditions.

Physiology

20. The effect of swilling carbohydrate, menthol or a combination on 40km cycling time trial in the heat

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Introduction: Both carbohydrate and menthol mouth swills have shown ergogenic effects under a variety of settings. The aim of the current study was to compare the effect of the aforementioned mouth swill solutions on 40 km time trial (TT) performance in the heat (32 °C, 40% humidity, 300kw radiant load) and investigate associated subjective measures (thermal comfort, thermal sensation, thirst, and RPE) every 5km. **Methods:** Six (6) recreationally trained male cyclists (31.8 ± 5.9 years, 178.2 ± 6.0 cm, 75.7 ± 10.0 kg) completed 3 trials, swilling either menthol (MEN), carbohydrate (CHO), or a combination (BOTH) at 10km intervals (5, 15, 25, 35km). **Results:** There was no statistically significant difference in 40km TT performance between mouth swills ($P = 1.00$), with MEN producing slightly quicker times on average (MEN 65:43 \pm 4:48, CHO 66:09 \pm 4:13, BOTH 65:57 \pm 3:58 min:sec). Subjective measures were not significantly different, however MEN showed small (0.2-0.6) and moderate (0.6-1.2) effect size increases on thermal comfort compared to CHO and BOTH 5km post swill. **Discussion:** The ability to activate receptors in the oral cavity may be responsible for improved athletic performance due to potential central activation. The ability to perceptually cool and/or fuel an athlete while exercising, especially in the heat, may allow for improved levels of thermal comfort and subsequently enhanced performance. **Take Home Message:** Results, however, indicate that while MEN showed a beneficial effect on making participants feel more comfortable while exercising in the heat compared to CHO or BOTH, 40km TT was not significantly different between solutions.

21. Lifestyle factors as an alternative to immune predictors of upper respiratory tract symptom risk in elite rugby union players

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Introduction: Recurrent illness detracts from training availability with significant impacts on athletic performance and success. Therefore, the aim of this study was to examine whether biomarkers or more accessible self-report lifestyle and behaviour data have the potential to predict elite rugby players risk for upper respiratory tract symptom (URTS) episodes. **Method:** A prospective longitudinal study was conducted in

elite southern hemisphere rugby union players. Salivary secretory immunoglobulin A (SIgA), salivary cortisol (S-cortisol), URTS, household illness, training load and wellness data including stress, mood, fatigue, muscle soreness and sleep quality were monitored for 8-months. **Results:** Univariate frailty model analysis demonstrated that illness in players' households and SIgA concentration independently predicted URTS risk. Household illness was the strongest predictor; players were almost three-fold more at risk for an URTS episode when illness in the household was present ($p = 0.002$). A significant reduction (25%, $p = 0.008$) in relative SIgA concentration was observed in players experiencing an URTS episode. **Discussion:** Incidence of household illness and SIgA concentration predicted URTS risk in elite rugby union players. Household illness was the strongest predictor of URTS risk and this finding has major implications beyond rugby players. Household illness monitoring is an accessible tool for all sports as it is cheap, can be done anywhere and anytime, and does not require a specialist to administer or analyse. **Take home message:** Household illness monitoring is a novel, cheap and accessible tool that practitioners can use in surrogate of SIgA to identify athletes' illness risk.

22. How hot do muscles get during resistance exercise?

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Introduction: It is well known that exercise increases body temperature, but the temperature of exercising muscle is under-examined. The muscle temperature response to resistance exercise remains almost unknown, yet is of interest as muscle heating per se can promote hypertrophy and protect against atrophy. The aim of this study was therefore to characterise muscle and core thermal responses to resistance exercise representing typical training regimes. We hypothesised that high repetition, short-rest exercise would be the most thermogenic. **Methods:** Five physically-active participants (2 female) undertook three work-matched resistance exercise sessions in a repeated measures design with a pseudo-randomised order. Unilateral bicep curls were used in sessions representing hypertrophy training (3x10 repetitions at 67% 1RM), endurance training (3x20 repetitions at 34% 1RM), and strength training (6x4 repetitions at 84% 1RM). **Results:** The three exercise regimes increased biceps brachii temperature by similar extent; 2.0 ± 0.8 °C for hypertrophy, 2.5 ± 1.0 °C for endurance, and 2.2 ± 0.5 °C for strength training (time: $p < 0.0001$; condition: $p = 0.47$; interaction: $p = 0.70$). The first third of the

exercise session accounted for $44 \pm 17\%$, $68 \pm 8\%$ and $60 \pm 10\%$ of the total rise for hypertrophy, endurance and strength regimes, respectively (condition: $p=0.06$). Following 15 min of supine recovery, almost half ($44 \pm 24\%$) of the muscle temperature increase was still evident (condition: $p=0.67$). No change in oesophageal temperature was observed across sessions (0.02 ± 0.13 °C; condition: $p=0.56$). **Discussion:** Preliminary results indicate that all three regimes of resistance exercise increase biceps brachii temperature substantially and for a prolonged period, whereas core temperature is barely affected. **Take home message:** Resistance exercise increased muscle temperature with little to no effect of regime.

23. Characterising the thermal effects of aerobic exercise in skeletal muscle.

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Introduction: Exercise-induced increases in core and skin temperature are well documented but muscle temperatures (T_m) are not. Increased T_m likely underlies some muscular

adaptation from aerobic training because they can occur with passive heating. Thus, we sought to preliminarily characterise T_m responses to four common patterns of such exercise. **Methods:** Five active participants (2 female) completed four single-legged cycling exercise sessions in randomised order on different days. Three were work-matched and one included low-volume sprint intervals. Sessions were: 1 x 15 min at 64% $\dot{V}O_{2peak}$ (CONT); 3 x 4 min at 79% $\dot{V}O_{2peak}$ (MIIT) 3 min apart; 10 x 1 min at 95% $\dot{V}O_{2peak}$ (HIIT) 1 min apart, and; 6 x 30-s Wingate's (SIT) 4 min apart. All sessions included 15-min supine recovery. **Results:** T_m in *vastus lateralis* (~25 mm depth) increased by 4.5 ± 1.3 , 4.7 ± 1.1 , 3.5 ± 0.9 , 3.1 ± 0.5 °C across sessions of CONT, MIIT, HIIT and SIT, respectively. A significant difference ($p<0.012$), was statistically evident only for the ~50% larger response in MIIT compared with SIT. Oesophageal temperature increased ($p<0.0001$) by $\sim 0.9 \pm 0.2$ °C, tending ($p=0.074$) to be higher in MIIT and HIIT. For work-matched points at ~33% total work, increases were, 3.7 ± 1.2 , 3.5 ± 1.5 , 2.1 ± 1.7 , 2.8 ± 0.7 °C, and equivalent between conditions ($p=0.178$). **Take home message:** Four vastly dissimilar patterns of 'aerobic exercise' increased T_m by 3 – 5 °C. Thus, if muscle temperature is an important driver of adaptation, any pattern of exercise may be effective, although it preliminarily appears that more sustained exercise causes more heating.

High Performance Sport

24. HPSNZ Innovation Programme

Murray, S.¹

¹High Performance Sport New Zealand

Innovation in sport is now commonplace amongst the best sporting nations across the globe. Where sporting performances are ever improving and margins of victory ever decreasing, it is essential that our practise as sports scientists, sports engineers, coaches and athletes is constantly changing and challenging the status quo. Predictive analyses suggest that a successful performance in the 2016 Rio Olympic and Paralympic games is unlikely to produce a podium finish in the upcoming Tokyo Games in 2020. This presentation will outline how the HPSNZ Innovation Programme deploys novel solutions, processes and interventions to maximise the likelihood of our athletes succeeding on the world stage.

25. Performance Technique Analysis delivery in the High Performance Environment: WHAT, HOW and WHY?

Evans, J.¹

¹High Performance Sport New Zealand

Performance Technique Analysis (PTA) is a key discipline of athlete performance support at High Performance Sport New

Zealand. This presentation will highlight how PTA provides support for coaches and athletes in the Rowing New Zealand environment during training and competition using technology and data to provide objective performance feedback.

26. Beating the heat in Tokyo

Kissling, L.¹

¹High Performance Sport New Zealand

Tokyo is anticipated to be the most thermally stressful Games to date. Temperatures are expected to peak between 28-34°C with an accompanying relative humidity of 48-68%; corresponding to a humidex ('Feels Like') temperature of 36-46°C (Gerrett et al., 2019). This environment is not only known to significantly impair a range of sporting performances (e.g., endurance, team sport) but also poses a serious health risk for athletes and staff. Back in 2016, High Performance Sport New Zealand, in partnership with the New Zealand Olympic Committee and Paralympics New Zealand, developed a heat management strategy to ensure that our athletes and staff can thrive and perform in the Tokyo Environment. This presentation will paint a picture of the Tokyo environment, describe the key aspects of our heat management strategy, and examine the challenges we have experienced and are likely to face during Games time.

27. Characterisation of core temperature response to an international rugby sevens tournament played in hot and humid conditions.

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²High Performance Sport New Zealand

³New Zealand Rugby

Introduction: Rugby sevens is a high-intensity contact sport, with tournaments typically involving 5-6 games across two days. It has been shown previously that there are game-on-game increases in core temperature (T_c) during tournaments, however, this has not been characterised in an environment similar to that expected at the Tokyo 2020 Olympic games. **Methods:** T_c was collected using ingestible telemetry pills in twelve male, non-heat-acclimated international rugby sevens athletes, during a

two-day tournament in Suva, Fiji. Cooling strategy use and environmental conditions were also measured. **Results:** Mean game environmental temperature was 29.3 ± 1.8 °C with 75 ± 3 % relative humidity. Mean baseline T_c (pre-warm up) was 37.4 ± 0.4 °C. Peak T_c in games 1-5 was 38.9 ± 0.5 °C; 38.9 ± 0.6 °C; 38.8 ± 0.4 °C; 39.1 ± 0.5 °C; and 39.1 ± 0.3 °C, respectively. During each game four to six athletes exhibited peak T_c over 39.0 °C. No pre- or per-cooling methods were used by any of the athletes. **Discussion:** Given that temperatures over 39.0 °C have been associated with reduced repeated sprint ability, heat acclimating prior to competition in hot environments, along with including pre- and per- and post-cooling strategies may help to limit consistent core temperature rise seen in the current study. **Take home message:** Competing in rugby sevens tournaments in conditions similar to those expected in Tokyo 2020 without heat acclimation or cooling strategies can result in core temperatures that are likely to decrease performance.

Physical Activity and Health

28. Muscle-strengthening exercise for general population health: Is it the “forgotten guideline”?

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Introduction: Physical activity guidelines are designed to improve long-term health, and consist of two main components – aerobic (≥ 150 min/week) and resistance or muscle-strengthening (MSE) exercise (twice/week). Adherence to aerobic guidelines is well documented, however, the MSE component is frequently overlooked and could be considered the “forgotten guideline”. **Methods:** A systematic literature search was conducted by two researchers independently using PubMed database, to identify publications reporting healthy, non-athlete adults’ adherence to MSE guidelines within Australia and New Zealand, returning only one relevant study. **Results:** No population level New Zealand data were found, however only 25% of Australian adults report meeting MSE guidelines, and 70% report no MSE despite its substantial benefits to mental and skeletal health and cardiovascular-related conditions (e.g. type 2 diabetes, stroke). **Discussion:** Self-reported adherence to MSE guidelines is alarmingly low, and measurement with wearable devices and other technology has proven difficult and unreliable. Hence, validated questionnaires (many evaluating only aerobic exercise) and other retrospective self-report methods (physical activity diaries) are relied upon, despite known recall bias and incomplete assessment of MSE. Furthermore, confusion may exist regarding classification of MSE; bench-press is a well-known MSE, whilst body-weight or band exercises may not be. The current lack of research, implementation and understanding of MSE may contribute to its “forgotten guideline” status. **Take home message:** Given the strong evidence for improved health with MSE, suitable methods to accurately and reliably quantify

MSE warrant dedicated research. Furthermore, promoting participation in and improving understanding of MSE is important for long-term public health.

29. Health behaviour survey in a New Zealand tertiary institution with a focus on physical activity

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Introduction: In the present research there were eight topics (physical activity, diet, alcohol consumption, drug use, smoking, risky sexual behaviours, general health practices and trauma) that were being investigated to determine whether there were any noticeable trends among students studying at the New Zealand tertiary institution. **Methods:** The method for the survey was based on the Total Design Method. An online health survey, using Qualtrics, was distributed to all enrolled students to obtain specific information on the diet, exercise, general health practice, smoking, risk taking sexual behaviours, alcohol consumption and trauma of students studying for a broad range of qualifications throughout Otago Polytechnic. Quantitative data was analysed using SPSS to determine frequency distribution and correlations in order to identify trends and patterns within the sample and to make comparisons with the previous survey. Trends relating to specific areas of study and health behaviours were of particular interest. **Results:** findings from the study are being used to inform the design and implementation of public health interventions designed by nursing students, thereby creating student lead health interventions. The identification of problem behaviours will enable students studying health related to create interventions to benefit fellow students across all disciplines at the institution.

Successive surveying enables the researchers and students to identify trends within the tertiary institution and inform the refinement of resultant interventions. **Take home message:** The ability to compare results from the student population survey (both 2017 and 2019) with larger scale, adult population surveys will enable the researchers to inform the design of student created and delivered health interventions, designed to tackle public health issues prevalent among young adults.

30. High Intensity Interval Training compared with standard care before major abdominal surgery

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Introduction: Improving peak oxygen consumption ($\dot{V}O_{2peak}$), measured during cardiopulmonary exercise testing (CPET), may reduce complications after surgery. We assessed the effectiveness of a supervised, preoperative High Intensity Interval Training (HIIT) program in increasing $\dot{V}O_{2peak}$ by $2\text{ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$ with a secondary aim of improving clinical outcomes. **Method:** Participants undergoing major abdominal surgery were randomised to standard care or 14 sessions of HIIT (3x/week over 4-6 weeks). HIIT sessions involved approximately thirty minutes of interval training on stationary cycles. Participants alternated between high and low intensity pedalling in order to reach 90% maximum heart rate during high intensity pedalling. Clinical outcomes included postoperative complications, postoperative morbidity survey, length of stay, and SF-36. **Results:** Of 63 participants, 46 completed both CPETs and 51 clinical follow-up. In our per protocol analysis, mean $\dot{V}O_{2peak}$ increased 14%, from $20.3\text{-}23.2\text{ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$ in the exercise group and 0.7%, from $21.8\text{-}22.0\text{ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$ in the control group. Change in $\dot{V}O_{2peak}$ was 2.87 vs. $0.14\text{ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$ ($p<.001$). Exercisers increased peak work rate by 25W, compared with no change in controls. There were no significant differences in clinical outcomes. Clinical outcomes that were most responsive to improved fitness were fewer postoperative complications (0.64 vs. 1.16 per patient, $p=.07$) and increased physical component score (PCS) of the SF-36 ($p=.07$), with the greatest difference in PCS six weeks

after surgery (42.9 vs. 36.6), suggesting a more rapid recovery. **Take home message:** There was a significant improvement in $\dot{V}O_{2peak}$ and peak work rate with preoperative HIIT. We also noted a trend towards fewer postoperative complications and more rapid recovery after surgery.

31. Accumulated or continuous exercise for cardiometabolic health

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Introduction: This study investigated the cardiometabolic response to five consecutive days of accumulated exercise, single-bout exercise and a no-exercise control. **Methods:** A three-arm randomised crossover-controlled study. Ten insufficiently active adults ($m=8$, $f=2$) completed moderate-intensity (50-70% heart rate reserve) treadmill walking as: three 10-minute bouts 30 minutes after meals (ACC); a single 30-minute bout (CONT) after dinner; and a 30-minute no-exercise control (NOEX) in a randomised order. A 2-hour oral glucose tolerance test and assessment of pulse wave velocity (PWV) was completed approximately 12h after the final bout. **Results:** Area under the 2h glucose curve was similar for CONT and ACC (mean difference $-14.0\text{mmol}\cdot\text{L}^{-1}\cdot\text{h}^{-1}$ [95%CI: -85.9 to 58.0]; partial $\eta^2 = 0.401$; $p = 0.671$), but both were lower than NOEX ($1037\text{mmol}\cdot\text{L}^{-1}\cdot\text{h}^{-1}$ [929 to 1144]). There was a large intervention effect for PWV (partial $\eta^2 = 0.214$; $p = .047$) with ACC lower ($6.0\text{m}\cdot\text{s}^{-1}$ [5.4 to 6.5]) than CONT ($6.9\text{m}\cdot\text{s}^{-1}$ [5.9 to 7.9]). **Discussion:** Accumulating exercise in multiple bouts each day is as effective as single-bout exercise for glucose regulation and possibly more beneficial for vascular compliance. **Take home message:** Frequent exercise bouts should be recommended as appropriate when tailoring exercise prescription to suit personal preference.

Physiology

32. Running economy and performance in three different running shoes

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Introduction: The Nike Vaporfly 4% shoe (NIK) is marketed as a tool that improves running economy and performance. We compared running economy (RE) and 3-km time-trial (TT)

performance in recreational runners wearing NIK, habitual (HAB) running shoes, and Saucony racing flats (SAU). **Method:** Nineteen male runners (age: 32.7 ± 12.0 y) attended 4 sessions ~7 days apart. The first session consisted of a $\dot{V}O_{2PEAK}$ test ($57.15\pm 7.41\text{mL}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$) to set RE speeds at 60, 70, and 80% of $\dot{V}O_{2PEAK}$. In the subsequent three sessions, treadmill RE and 3-km TT performances were assessed in the three shoes in a counterbalanced design. **Results:** RE was improved in NIK (4.0%, $p=0.0014$, effect size $d: 0.30$) and SAU (2.6%, $p=0.0022$, $d: 0.20$) compared to HAB, but was similar between NIK and SAU (1.5%, $p=0.8401$, $d: 0.12$). NIK TT performance

(11:00.0±1:04.4 min:s) was superior to HAB by 16.0 s (2.4%, $p=0.0016$, $d: 0.23$) and SAU by 12.5 s (1.8%, $p=0.0114$, $d: 0.18$), with similar performances between HAB and SAU (0.6%, $p=0.4582$, $d:0.05$). Two runners ran their best TT in SAU, 4 in HAB, and 13 in NIK. **Discussion:** NIK significantly improved RE and 3-km TT performance versus HAB and SAU. Our findings align with previous studies on elite runners and indicate that the “4%” benefit extends to male recreational runners and RE at relative speeds. Individual responses ranged from -3.8% to 8.6%. No forefoot runner performed their best TT in NIK (-0.01% to -3.8%). **Take home message:** NIK improved RE and effectively enhanced running performance in most male recreational runners.

33. Functional threshold power is an estimate of critical power

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Introduction: Functional threshold power (FTP) is the endurance performance measure adopted by cyclists which estimates maximum power output for one hour. Training zones are derived as fractions of FTP with supposed correlations to blood lactate ([bLa]). However, little physiological evidence exists to support FTP and its training zones. **Methods:** Ten recreationally to moderately trained cyclists performed a maximal test to determine peak oxygen uptake ($\dot{V}O_{2peak}$: 51.9 ± 7.4 ml·min⁻¹·kg⁻¹) and maximal aerobic power (MAP; 335 ± 59 W), three time trials (TT - 3, 8 and 12 min) and three constant-load trials to exhaustion (TTE) for determination of critical power (CP) from two trial formats (TT: 240 ± 41 W; TTE: 251 ± 49 W). A sub-maximal test determined lactate threshold (LT; 192 ± 41 W) and [bLa] = 4.0 mmol.L⁻¹ ([bLa]₄; 229 ± 43 W), and a 20 min TT provided the FTP estimate (236 ± 45 W). Participants performed one final TTE trial at FTP (45 ± 12 min). **Results:** FTP was not different to CP-TT ($P = 1.000$), CP-TTE ($P = 0.216$), or [bLa]₄ ($P = 1.000$), and positively correlated to CP-TT ($r = 0.98$, $P < 0.01$), CP-TTE ($r = 0.97$, $P < 0.01$), and [bLa]₄ ($r = 0.85$, $P < 0.01$). **Discussion:** These data reveal strong positive correlations of FTP with CP and [bLa]₄ which substantiates previous literature supporting FTP as a single test estimate of endurance performance and CP. **Take home message:** An alternative model of FTP training zones based on LT, CP, and MAP was created with increased physiological validity.

34. The athlete's vein: Venous adaptations of the lower limb in endurance athletes

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Introduction: Regular endurance exercise induces an athletic phenotype of the heart and arteries. It also leads to expanded blood volume, most of which resides in veins and is mobilised

during exercise. However, there are few studies investigating how chronic exercise changes the venous system. The aim of this study was to assess the effect of endurance exercise on morphology and function of the lower-limb deep and superficial veins. **Methods:** Twenty endurance athletes (training >6 h/wk for >5 y) and twenty untrained controls (<2.5 h/wk) had vein diameters and flow volumes measured using ultrasound, and calf venous volume dynamics measured using air plethysmography. Measures were taken at rest, before and after exercising for 30 min at 65-75% heart rate maximum. **Results and Discussion:** Before exercise, three deep veins – draining large calf and thigh muscles – were larger in athletes than non-athletes. After exercise, the recovery of common femoral vein blood flow was remarkably similar between groups, despite athletes having covered more than twice the distance. Athletes had larger venous blood volume in the calf before exercise (160 ± 41 vs. 131 ± 41 mL, $p=0.03$), although this reduced after exercise in athletes (by $19 \pm 23\%$, $p<0.001$), which may reflect more efficient return of blood to the heart to maintain blood pressure. **Take home message:** When compared to untrained controls, athletes demonstrated larger muscular veins, larger resting calf venous volume and an improved venous blood flow recovery profile post-exercise. Endurance training provides adaptations in venous morphology and function in the lower limb to compensate for the demands of regular endurance training.

35. The potassium-carbohydrate interaction as a potential mechanism of skeletal muscle fatigue during high-intensity exercise

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Introduction: During intense exercise major potassium (K⁺) disturbances occur across muscle cell membranes together with a simultaneous decline of intramuscular glycogen content. It is known that exposure to raised extracellular [K⁺], ([K⁺]_o), *per se*, using [K⁺]_o values similar to those measured during exercise, impairs contraction in isolated muscles from animals. The aim of this study was to determine whether such K⁺-effects are exacerbated when glycogen levels are lowered experimentally in animal muscles. **Methods:** Isolated soleus muscles from mice were exposed to normal (4 mM) or raised (11 mM) [K⁺]_o physiological saline solutions at 37°C. Isometric contractions were evoked with electric field stimulation using transverse wire electrodes. Muscle glycogen was lowered using prolonged exposure (i.e. 2-4 hr) to saline solutions with 0 versus 11 mM glucose (i.e. 0G versus 11G), or by fatiguing muscles with repeated tetanic stimulation then allowing recovery at 0G or 11G. Isometric force, resting membrane potential and intracellular action potentials were recorded. Muscles were frozen at the end of experiments and assayed for glycogen content (glucosyl units). **Results:** Prolonged incubation with 4K+0G lowered muscle glycogen to about one half of that at 4K+11G. Then at 11 mM [K⁺]_o the peak tetanic force fell to

$67 \pm 13\%$ initial ($n = 19$) (mean \pm SD) at 11G and to $22 \pm 14\%$ initial ($n = 14$) at 0G. Glycogen was $598 \pm 215 \mu\text{mol} \cdot \text{g}^{-1}$ dry wt. ($n = 8$) at 11K+11G and $247 \pm 161 \mu\text{mol} \cdot \text{g}^{-1}$ dry wt. ($n = 8$) at 11K+0G. The resting membrane potential and action potential peak were both reduced at 11 mM $[\text{K}^+]_o$, i.e. to about -59 mV and -12 mV, respectively, with no difference at 0G and 11G. Notably, the percentage of excitable fibres was more markedly reduced at 11K+0G (to 29% initial) in contrast to 11K+11G (to 58% initial). After fatigue and recovery at 4K+11G, exposure to 11 mM $[\text{K}^+]_o$ reduced peak tetanic force to $78 \pm 14\%$ initial (glycogen $544 \pm 20 \mu\text{mol} \cdot \text{g}^{-1}$ dry wt. ($n = 4$)) and after fatigue

and recovery at 4K+0G, 11 mM $[\text{K}^+]_o$ reduced peak tetanic force to $39 \pm 19\%$ initial (glycogen $339 \pm 48 \mu\text{mol} \cdot \text{g}^{-1}$ dry wt. ($n = 7$)). The peak tetanic force at 11 mM $[\text{K}^+]_o$ using all experimental conditions, (as % initial), was linearly correlated with muscle glycogen content ($r = 0.66$). **Discussion:** There is an association between force depression at raised $[\text{K}^+]_o$ and muscle glycogen content in mouse soleus muscles, suggestive of a K^+ -carbohydrate interaction. **Take home message:** The implication is that the combined effect of these two factors may contribute to skeletal muscle fatigue, and this is likely to be important in team sport events.

Strength and Conditioning

36. The reality of small-sided games in rugby union.

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Introduction: Small-sided games (SSGs) are prominent within the football codes' practice and sports science, valued for their sport-specific conditioning potential. However, a lack of systematic approach to SSG research limit the ability to make definitive evidence-based recommendations in rugby. This research aimed at investigating the use of SSGs in rugby union. **Methods:** An electronic survey was conducted to question coaching staff on their SSG-training practice preferences. **Results:** 32% of respondents coach on semi-professional level or above. Most fulfil the roles of head coach (52%), S&C coach (21%), and assistant coach (18%). 83% of coaches use SSGs every 1-3 sessions. 3v3 – 5v5 – 7v7 are the most popular formats. Technical skill development (26-28%) and fun (25-30%) form the main motivation for SSG application at the lower levels, whereas technical skills (21-29%) and physical conditioning (21-35%) are key for SSGs at the higher levels. Touch rules are favoured for higher-level athletes (47-64%) by assistant (50%) and head coaches (43%), whilst school (49%), local (47%), and S&C coaches (62%) prefer union rules. 3 bouts (46%) of 1:1 to 5:1 work-rest ratio with backwards passing (71%) is most commonly used. **Discussion:** SSGs are widely implemented in rugby union practice. Professionals seem to adhere to the scientific evidence regarding conditioning more than amateurs. Application clearly differs regarding level, function, experience, and target group. Further structured research should enable optimal evidence-based recommendations to be communicated to (conditioning) coaches. **Take home message:** SSGs are relevant to rugby union. Differentiation between roles, levels, and athletes is key. Evidence-based and contextual individualisation optimises conditioning through SSGs.

37. The effect of upper limbs Thera-Band training on the tennis service speed of adolescent tennis players

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Introduction: Thera-Band is a type of elastic resistance and commonly used in a fitness setting. However, the effects of a Thera-Band strength training on the tennis service speed has not been investigated. Therefore, this study examined the effect of Thera-Band training on the tennis service speed of adolescent tennis players. **Method:** 40 competitive male adolescent tennis players, aged 10-19 years (age 14.5 ± 2.909) completed a 8 week training intervention. Participants were, divided into Thera-Band Training Group (TTG, $n=20$) and Control Group (CG, $n=20$). Both groups continued with their regular technical and tactical tennis training during the 8 weeks, with the TTG receiving additional Thera-Band training twice a week ($60 \text{ min} \cdot \text{day}^{-1}$). Participants were tested for service speed, handgrip strength (right & left hands) and power of upper limbs (Medicine ball throw) performance pre and post the 8-week Thera-Band Training (TT). **Results:** The TTG significantly ($P \leq 0.05$) improved service speed ($P=0.000$), grip strength (R.H & L.H) power of upper limbs, whereas the CG shows significant changes only in the right hand ($P=0.028$). The service speed of TT was significantly higher as compared to the CG ($P < 0.05$). **Discussion:** The main finding of this study reveals that TT, concurrent with regular tennis training, considerably improves tennis service speed in adolescents compared to technical tennis training alone. **Take home message:** Thera-Band training improves the tennis service speed of adolescent tennis players. Therefore, it can be recommended to the players and coaches in addition to the regular technical training.

38. The strength and conditioning coach: Breaking free from signature pedagogies

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Introduction: Early strength and conditioning coaches (SCC) came from a tradition of weightlifting, so strength and conditioning education has traditionally been grounded in the exercise sciences. With the evolving challenges of athlete preparation there have been calls for SCCs to think and act a more like coaches and to be more reflective and critical practitioners. **Argumentation:** Shulman (2005) posits that a profession's 'signature pedagogies' guide how that profession acts and evolves. The teaching and learning methods that professionals are exposed to will influence their initiation into the profession, and how they ultimately think, practice, and conduct themselves. Strength and conditioning coaches are typically educated through curricula emphasising biophysical sciences, positivistic paradigms and techno-rational thinking. Without encouragement to view knowledge as fluid, contestable, and fallible, potentially empowering and complementary pedagogies may be discounted, marginalised, or unavailable to these professionals. This paper explores SCC education through a 'mapping' of a professional competence framework against the knowledge, competencies, and attributes specified by the key S&C accrediting bodies. **Take home message:** By exploring the contemporary S&C landscape, pathways can be identified and negotiated for integrating psychological, sociological, and cultural pedagogies. These lenses will help expand S&C signature pedagogies and contribute to the professional competence of the SCC.

39. Working conditions of strength and conditioning coaches in New Zealand and the Pacific Islands

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Introduction: The strength and conditioning coach is a sport service provider that plays an integral role in preparing an athlete for competition. The bio-physical elements of strength and conditioning are well-known, however little information is available on the working conditions of the coaches. **Method:** An online, in-depth, survey was used to gather quantitative data from coaches within New Zealand and the Pacific Islands. Respondents were categorised into the three most common employment styles for this population, (1) permanently-employed, (2) self-employed and (3) other-employed in order to compare responses. **Results:** 72 coaches from New Zealand (n = 67) and the Pacific Islands (n = 5) responded to the survey. Findings revealed the working conditions of coaches within this region vary and depend on the style of employment. Those employed permanently had the greatest industry experience (mean = 8.69 years), have a tertiary level qualification (100%) and hold or are working towards gaining an industry specific accreditation (85.18%). They receive higher remuneration (mean = \$67687.86), have benefit packages (77.77%) and work longer hours than self-employed and other-employed coaches (p < 0.05). **Discussion:** Permanent employment appears to be the most rewarding form of employment for coaches in this region, however it does not come without difficulties relating to work conditions. These pressures include travelling away from home, 10+ hour days and hours that frequently exceed contracted expectations. **Take home message:** Theoretically, this research provides initial data for coaches working within this region and builds upon the research for this topic globally. Applied, this research allows for emergent coaches to make informed professional development and career-related decisions.

Nutrition and Metabolism

40. Exercise and the microbiota: An update

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Introduction: Our understanding of the role of the microbiota in health and disease has grown substantially in recent years. Gut microbiota influence metabolism, (including nutrient availability and substrate oxidation), immune function, cognition and behaviour, gut health and numerous down-stream effects on systemic health. Endogenous and exogenous factors influence the microbiota and their functionality including diet and exercise. The purpose of this presentation is to provide a brief review of research on exercise and the microbiota/microbiome, with specific attention to recent work on exercise and metabolism, and implications for performance and health. **Method:** Databases searched included Google Scholar and Ovid Med-line with key words "Microbiome" and

"Exercise". The "cited by" feature was used and additional references were found by examining reference lists of selected references. **Results and Discussion:** Early research, in animals, indicated that exercise increases phylogenetic diversity and alters the relative proportionality of bacterial genera. Exercise induces positive alterations in microbiota, short-chain fatty acid (SCFA) production and metabolism, including an increase in butyrate producing bacteria, and can attenuate dysbiosis occurring on a high fat diet. Recently, elite marathon-runners demonstrated increased post-marathon *Veillonella spp.* that metabolise lactate (Scheiman et al, 2019). Inoculating mice with *Veillonella atypical*, isolated from these runners, enhanced their endurance performance. This and other work on microbiota and substrate metabolism offer a ripe area for further research. **Take home message:** We live in symbiosis with our gut microbiota. Exercise has positive effects on our microbiota and, in turn, the microbiota can influence our metabolism, health and possibly performance.

References:

Scheiman, J., Lubner, J.M., Chavkin, T.A., MacDonald, T., Tung, A., Pham, L-D., ... Kostic, A.D. (2019). Meta-omics analysis of elite athletes identifies a performance-enhancing microbe that functions via lactate metabolism. *Nature Medicine*, 25, 1104-1109.

41. The effect of bicarbonate supplementation on plasma acidosis and peak power during a simulated 4000-m individual pursuit on a bicycle ergometer in elite athletes

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Introduction: Severe plasma and/or muscle acidosis has been associated with fatigue during supramaximal exercise. Due to the importance of the end-spurt in supramaximal events understanding the role of acidosis on limiting the ability to produce power late into a race could provide a competitive advantage. Aims: To determine the effect of NaHCO₃ on plasma acidosis and peak power output after a 3-min fixed-intensity supramaximal cycling time-trial simulating ~75% of a 4000-m individual pursuit. **Methods:** Twelve elite male cyclists ingested 0.3 g·kg⁻¹ body mass of either NaHCO₃ (BIC) or placebo (PLA) 75 min prior to a standardized warm up in a double-blind, randomized crossover design. Performance testing began with an initial 6 s peak power output (PPO1). After 10 min of passive rest participants then completed a 3 min fixed-intensity time-trial at 105% of the power at $\dot{V}O_{2peak}$ and a second 6 s peak power output (PPO2). **Results:** There were no differences between PPO1 and PPO2 in the percentage decrease of peak power ($42.3 \pm 12.6\%$ BIC vs. $45.7 \pm 13.7\%$ PLA, mean \pm SD, $P > 0.05$), peak torque ($P = 0.34$) or peak cadence ($P = 0.42$). Plasma bicarbonate concentration ([HCO₃⁻]) was higher in BIC vs. PLA immediately following PPO1 (33.9 ± 2.7 vs. 27.0 ± 2.2 mmol·L⁻¹, $P < 0.001$), and PPO2 (26.7 ± 2.9 vs. 22.1 ± 2.7 mmol·L⁻¹, $P < 0.001$). Plasma pH was also higher in BIC at PPO1 (7.38 ± 0.05 vs. 7.29 ± 0.03 pH units, $P < 0.001$) and PPO2 (7.20 ± 0.12 vs. 7.13 ± 0.14 pH units, $P < 0.001$). **Take home message:** Differences in plasma acidosis did not appear to affect the decrease in PPO following a simulated 4000-m individual pursuit cycling time-trial in elite athletes.

42. Comparison of the effects of different forms of caffeine supplementation on 5-km running performance

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Introduction: Caffeine is a commonly used ergogenic aid which can be administered via oral consumption or sublingual delivery. Currently, there are few studies comparing the effects of different caffeine delivery modes on sports performance. This study examines the effects of different modes of caffeine supplementation on running performance. **Methods:** Fourteen runners completed a series of 5-km trials following ingestion of

a placebo (P) or three alternate forms of caffeine supplement. Trials were randomized with caffeine (dose ~3-4.5 mg·kg⁻¹) administered 15 minutes before each trial via chewing gum (CG), dissolvable mouth strips (CS) or tablet (CT). **Results:** Compared to P, all caffeine supplements led to similar enhancements in running performance with a mean ($\pm 95\%$ CL) overall effect across all supplements of $1.4\% \pm 0.9\%$. Individual caffeine treatment effects (CG= $0.9 \pm 1.4\%$, CS= $1.2 \pm 1.0\%$ and CT= $2.0\% \pm 1.1\%$) were not significantly different ($p > 0.05$) from each other, however, CT trials were significantly faster ($p = 0.02$) when compared with P. There was no significant difference in runners heart rate or rate of perceived exertion across any of the performance trials. **Discussion:** The findings show that irrespective of delivery form, moderate dose caffeine supplementation produces similar worthwhile gains in 5-km running performance.

43. Menthol mouth rinsing does not improve strength or power performance

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Introduction: Capsaicin ingestion has been shown to improve strength performance, possibly due to its analgesic effects and ability to facilitate Ca²⁺ release from the sarcoplasmic reticulum. Menthol, a capsaicin antagonist, has similar analgesic properties to capsaicin and may also have a depolarising effect upon membranes – hence, we investigated the effect of menthol mouth swilling upon strength and power performance. **Methods:** Nineteen (10 male; 9 female) participants undertook three attempts of an isometric mid-thigh pull (IMTP), vertical jump and six-second Wingate. Recovery between all efforts was three minutes, with participants undertaking a familiarisation session prior to experimental trials (control; menthol) which were performed in a randomised, counterbalanced order. Testing order was kept consistent so as to minimise any variance due to post-activation potentiation. Standardised mean differences were calculated (Cohen's *d*) to quantify the magnitude of between condition differences, and interpreted as follows: 0 – 0.2 *Trivial*, 0.2 – 0.6 *Small*, 0.6 – 1.2 *Moderate* and > 1.2 *Large*. **Results:** *Small* differences between familiarisation and experimental trials were found across IMTP and vertical jump trials, whereas with Wingate performance familiarisation only *trivially* differed to control and menthol. Control and menthol trials were *trivially* different across all metrics. **Take home message:** Menthol swilling does not improve repeated strength of power performance, following a familiarisation trial.

Sports Medicine and Rehabilitation

44. The effect of altitude on concussion in university (American) football playersTreacy, J.^{1,2}, Heflin, L.²¹University of Waikato²New Mexico Highlands University

Introduction: Concussion causes varying degrees of brain damage in athletes, but factors affecting severity and damage to neuropsychological domains are complex and not well-understood. A potential contributing factor is altitude; current research is mixed on whether altitude acts as a risk or protective factor, but much of this research has not been done at altitudes high enough to cause physiological changes. This study seeks to clarify the role altitude plays in concussion symptoms and recovery. **Methods:** We collected data on concussions sustained at or around 1,966m among university football players. Thirteen American football players at New Mexico Highlands University (N = 13) consented to participate and were administered the 40-minute neuropsychological battery to examine domains affected by concussion like attention, working memory, verbal fluency, and depressive symptoms before and after the 2016 football season. **Results:** In total, there were 5 concussed players and 8 non-concussed (control) players. All five concussed players had persistent neurological impairment at the post-season assessment, most notably increases in depression symptoms ($F = 6.335$, $p = .029$), declines in processing speed ($F = 7.073$, $p = .024$), and declines in verbal learning/memory ($F = 5.777$, $p = .037$). Additionally, two players (one who sustained a concussion and one who did not) were re-administered the battery within 7 days post-injury. The concussed player experienced acute deficits in most domains and demonstrated incomplete recovery on measures of depression, verbal learning/memory, and switching. **Take home message:** Concussions sustained at moderate altitudes may not recover within the frequently cited 10-day window.

45. OUCH: responses to a new model of contusion injuryBarnes, M.J.¹¹School of Sport, Exercise and Nutrition, Massey University

Introduction: Previous studies have used animal models or observational methods to understand the injury and recovery processes associated with impact related muscle contusion. However, to the author's knowledge, an ecologically valid model of contusion injury has not previously been developed in human subjects; therefore, that was the aim of this study. **Method:** Four groups of eight males had a load of either 4.2, 5.2, 6.2 or 7.2kg dropped from 62cm onto the contracted *vastus lateralis* of one leg. Maximal voluntary ($\dot{M}VC$) and electrically ($\dot{E}MVC$) evoked muscle function, pain and creatine kinase (CK)

were measured prior to impact and 30 min, 24, 48 and 72h post-impact. Additionally, oedema was quantified by MRI 24h post-impact. **Results:** $\dot{M}VC$ and perceptions of pain changed over time (both $p < 0.001$) and differed between loads (both $p < 0.05$). Similarly, $\dot{E}MVC$ changed over time ($p = 0.006$), however no difference was observed between loads ($p = 0.55$). Volume of oedema was different between loads ($p = 0.016$) with the greatest volume seen with 7.2kg. No change in CK was observed. **Discussion:** Changes in muscle function, pain and oedema, often in the absence of elevations in CK, are typical symptoms of contusion injury, therefore all of the loads used resulted in muscle contusions of varying magnitudes. The greatest responses were observed with the heaviest load suggesting that 7.2kg is "safe" and effective for bringing about a significant, experimental contusion injury. **Take home message:** This study may be the first to develop an ecologically valid contusion injury in human subjects.

46. Application of the new Samsung S-Patch electrocardiography device in an exercise-based rehabilitation programmeRickman, E.¹, Nathu, D.¹, Reading, S.¹¹Department of Exercise Sciences, The University of Auckland, New Zealand

Introduction: The aim of this study was to determine the feasibility of using a portable electrocardiography (ECG) device (Samsung S-Patch) to determine the day-to-day variability in supraventricular (SVE) and ventricular ectopy (VE) burden in chronically ill older adults attending a community-based exercise rehabilitation programme. **Methods:** Seventy patients (63 ± 14 yrs) with various chronic disease conditions attended The University of Auckland Health and Rehabilitation Clinic. An ECG recording was obtained during one or more of their supervised exercise sessions. Each ECG recording was uploaded to the Samsung web-portal for analysis using SDS-Cardio (Samsung) rhythm detection software. **Results:** At rest 10% of individuals had occasional SVE or VE. The ECG recordings had high signal quality with only 9% of the total wear time lost to artefact. SVE and VE burden during a single exercise session were low at $0.6 \pm 2\%$ and $1.3 \pm 3\%$ of total beats respectively. Despite a low overall SVE and VE burden during a single session, ectopy was not stable when measured across 3 exercise sessions (highest VE; $2.5 \pm 4.5\%$ vs. lowest $0.66 \pm 1.5\%$ $p < 0.05$. Highest SVE $1.54 \pm 2.6\%$ vs. lowest $0.2 \pm 0.7\%$ $p < 0.05$). **Discussion:** The S-Patch ECG is a simple device for monitoring cardiac dysrhythmia in an exercise rehabilitation setting. When used for monitoring across multiple exercise sessions this device facilitated the detection of new and undocumented dysrhythmia in 5 of 70 patients, even though there were low overall and variable rates of SVE and

VE ectopy. **Take home message:** This low cost approach to patient monitoring and screening can improve patient care in outpatient rehabilitation settings.

47.A crossover comparison of four cardiopulmonary exercise testing modalities in severe lower-limb osteoarthritis patients

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Introduction: Cardiopulmonary exercise testing (CPET) is the gold standard for cardiorespiratory fitness ($\dot{V}O_{2peak}$) assessment. Traditionally performed on a cycle, CPET can be difficult to perform for those with lower-limb osteoarthritis (OA). The purpose of this study was to compare CPET variables on four different exercise modalities, in patients with severe lower-limb

OA. Methods: In this crossover study, fifteen participants (10 female; age = 68 ± 7 y; body mass index = 31.4 ± 4.1 kg m⁻²) scheduled for hip (n=5) or knee (n=10) arthroplasty completed CPET on a cycle, treadmill, cross-trainer and arm ergometer. $\dot{V}O_{2peak}$, anaerobic threshold (AT) and peak heart rate (HR_{peak}) were measured, then analysed using a repeated measures analysis of variance. **Results:** $\dot{V}O_{2peak}$ was greater on the treadmill, cross-trainer and cycle (21.5 ± 4.6 , 21.2 ± 4.1 and 19.4 ± 4.2 ml min⁻¹ kg⁻¹, respectively) compared to arm ergometer (15.7 ± 3.7 ml min⁻¹ kg⁻¹; $P=0.001$). AT was 1.3-1.7 times higher on the cross-trainer, treadmill and cycle, compared to the arm ergometer (8.6 ± 1.8 ml min⁻¹ kg⁻¹; $P=0.001$). HR_{peak} was higher on the cross-trainer compared to the arm ergometer (148 ± 19 vs. 134 ± 17 beats min⁻¹; $P=0.001$), but not different to cycle or treadmill modalities (143 and 139 beats min⁻¹ respectively, $P>0.23$). **Discussion and take home message:** Lower-limb CPET modalities resulted in higher $\dot{V}O_{2peak}$ and AT values than arm ergometry in patients with severe lower-limb OA. The presence of OA did not preclude patients from performing CPET using these modalities.

Home Straight

48. Cerebral blood flow regulation in severe heat stress: effect of the heat source

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Introduction: Cerebral blood flow (CBF) decreases with heat strain primarily due to decreased CO₂, which is a consequence of hyperventilation. Other mediators of CBF such as blood pressure, cardiac output and sympathetic activation are differentially affected depending on the mode of heating. We used three different modes of heat stress to: 1) elucidate the mechanisms underlying the changes in CBF with incremental severe heat strain; and 2) assess how different modes of heat stress affect thermal tolerance and intracranial pressure (ICP). **Methods:** Fourteen fit participants (7F) completed three heat exposures [spa (40°C), wet sauna (46°C, 60%rh) and cycling in the heat (45% $\dot{V}O_{2peak}$ with water-impermeable clothing)] to thermal tolerance or 40°C core temperature (T_c; oesophageal). Middle/posterior cerebral artery blood velocity (MCA and PCAv; transcranial Doppler), blood pressure, ventilation and end-tidal CO₂ (PetCO₂) were measured at each 0.5°C increment in T_c. Cardiac output was measured at each 1°C increment and optic nerve sheath diameter (ONSD) was measured at baseline and at thermal tolerance. **Preliminary results:** Hyperventilation was most pronounced with the two passive conditions, dropping PetCO₂ to 28 ± 5 and 26 ± 2 mmHg in the spa and sauna, respectively, at a matched T_c 3°C above baseline (n=7). PetCO₂ dropped to 33 ± 3 mmHg with cycling to +2.5°C T_c (n=6). Consequently, MCAv and PCAv were decreased most in the two passive conditions (MCAv: -28%, PCAv: -26% in spa; MCAv: -29%, PCAv: -32% in sauna) compared to

exercise (MCAv: -16%, PCAv -14%). **Take home message:** ONSD and cardiac output data are being analysed and will be presented at the conference alongside the full dataset of 14 subjects.

49. Using inertial measurement units to determine the potential efficacy of a motor analogy for improving landing from self-initiated falls

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Introduction: A major concern in countries with an aging population is the increasing rate of injuries due to falling. Landing safely from a fall can reduce the likelihood of injuries, but is difficult to learn late in life. Implicit motor learning approaches, such as analogy instructions, have been shown to be effective methods of learning for older adults. The aim of this study was to investigate whether a motor analogy instruction affects biomechanical characteristics of landing on the ground. **Method:** Ninety young adults were randomly divided into analogy and control groups. After attaching inertial measurement unit (IMU) sensors to the lower back and wrists of participants, they self-initiated 3 falls (backward, forward, sideways) onto a soft mattress. The participants in the analogy group were provided with landing instructions using a motor analogy (i.e., fall like a snowflake), whereas participants in the control group did not receive landing instructions. A single magnitude vector was calculated from the tri-axial accelerometer data recorded and relevant biomechanical variables were extracted. **Results:** The results indicated that participants in the analogy group displayed significantly higher free-fall duration (s), lower maximum acceleration (g) in all

sensors, and lower Jerk values (g/s) in both wrist sensors compared to the control. No significant interactions were evident between group and fall direction. **Discussion:** These findings suggest that a motor analogy affects biomechanical variables associated with landing (regardless of the direction of the fall). **Take home message:** Using motor analogies may be useful as a landing strategy to reduce risk and severity of fall-related injuries.

50. Float tanks for improving athletic recovery: FAD or feasible?

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Introduction: The professional sport setting has seen an emergence of new technologies and strategies used to expedite recovery from training and competition, often without any research evidence to support such techniques. Flotation-restricted environmental stimulation therapy (FLOAT) is one of these strategies that has grown in the athletic industry, requiring further research. **Method:** Study 1 involved tracking the mood-state and muscle soreness of 60 elite athletes across a range of

sports pre and post FLOAT. Study 2 involved 19 team-sport athletes completing two trials; FLOAT (one-hour of FLOAT recovery following exercise) and CON (passive recovery). Performance and pressure-to-pain algometer measures were taken pre and post exercise and the following morning. Perceived muscle soreness (MS) and physical fatigue (PF) were recorded up to 24h post testing. Salivary cortisol samples were collected pre and post exercise and post recovery. Sleep was monitored via wrist-actigraphy. **Results:** In study 1, a single FLOAT session significantly enhanced 15 of the 16 mood-state variables ($p < 0.05$) and also lowered perceived muscle soreness ($p < 0.01$). In study 2, FLOAT was found to significantly enhance jump ($p = 0.05$), 10m sprint ($p = 0.01$) and 15m sprint performance ($p = 0.05$), increase pressure-to-pain thresholds (indicating less sensitivity) across all muscle sites (p 's < 0.01) and lower MS and PF 12h post when compared to CON ($p < 0.05$). All sleep measures resulted in small to moderate effects in favour of FLOAT. **Discussion and take home message:** FLOAT may prove to be an effective method of exercise recovery, improving mood-state, performance, pressure-to-pain threshold, perceived MS and PF, and sleep quality.

Poster Presentations

51. Acute effects of blue light on motor control and cognition in older adults

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Introduction: Falls are a major economic burden and risk factor for mortality in older adults. Over half of all ACC claims by people 65+ are a consequence of falling, costing an estimated ~\$1,700 million in 2010. Blue light interventions can improve cognitive function and performance in fine motor tasks, but the potential impact on motor function with relevance to falling is unknown. **Methods:** Sixteen older adults [age 74 ± 8.1 y (65 to 82)] participated in four counter-balanced sessions with light delivered visually [Luminette®: (placebo/blue-enriched)] and/or aurally [Human Charger®: (on/off)] for 12 minutes. Motor function was assessed using the OptojumpNext® (Microgate, Italy) where participants were asked to lift and plant their right leg from a double-leg stance as quickly as possible in response to an unexpected visual cue. Cognitive function was assessed using computer-based executive function test (Eriksen Flanker Task; PEBL V2.1). Both tests were assessed before and after the light intervention. **Results:** Motor function was significantly enhanced ($p = 0.03$) with a large effect size ($d = 1.13$) in the visual blue-light relative to the placebo condition. No effects of the light intervention occurred in measures of cognitive function. **Discussion:** The brief light intervention was capable of altering measures with potential relevance to fall risk in older adults. Specifically, the ability to rapidly respond and re-plant the foot following a disturbance could decrease the likelihood of falling. **Take home message:** Novel light interventions may provide a potential countermeasure to decrease the financial and human costs of falls.

52. Effects of traditional Chinese meridian massage combined with soymilk supplementation on post-exercise recovery

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Introduction: This study investigated the combined effects of Chinese meridian massage (CMM) and soymilk supplementation on muscle damage and post-exercise recovery. **Method:** Nine healthy young adults (6M/3F; age: 24.3 ± 0.5 yrs old) completed two trials in a counter-balanced order: 1) CMM + placebo (CMM/P), and 2) CMM + soymilk (CMM/S). On Day 1, participants performed a 1st 5-km time trial (TT) and continued for a further 15-km self-paced cycling after a 30-s

break (20 km total). The CMM (15 min) was performed 45 min post-exercise. The first and second doses of soymilk/placebo (300 ml/dose) were provided immediately and 60 min after the 20-km cycling. On Day 2, participants performed a 2nd 5-km TT to assess the recovery. We periodically measured heart rate, systemic oxygen saturation (SpO₂), blood creatine kinase (CK) and uric acid (UA), TT performance, and work completed. **Results:** There were no differences in heart rate or SpO₂ during exercise and recovery between trials. 5-km TT performance and work output was unaltered between trials. However, the exercise-induced increases in circulating CK and UA were significantly lower in CMM/S than in CMM/P ($p < 0.05$). **Discussion:** We demonstrate that provision of soymilk to Chinese meridian massage after strenuous exercise effectively suppressed endurance exercise-induced muscle damage, reflected by the lower responses in circulating CK and UA, but this does not promote the recovery of exercise. **Take home message:** The addition of soymilk to Chinese meridian massage may be effective to decrease endurance exercise-induced muscle damage.

53. Neck strength in Rugby Union players: A literature review

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Introduction: Concussion is the most prevalent injury in professional Rugby Union. Neck strengthening is one strategy of potential protective value for concussion. We aimed to examine the scientific literature addressing neck strength in Rugby Union with a focus on the potential role of neck strength on injury incidence. **Method:** The first author (CC) performed a systematic search in June, 2019, to locate published peer-reviewed articles from four electronic databases. Studies included were original research conducted with Rugby Union that evaluated neck strength, neck-strengthening interventions, and/or head or neck injury outcomes. Studies were not excluded based on sex, age, level of competition, or study design. **Results:** 106 articles were identified using the search strategy, with 14 articles meeting inclusion. These articles tested 1066 male players (average: 76 participants per study), with 7 (50%) studies in professional, 4 (28.5%) schoolchildren, 2 (14.2%) semi-professional, and 2 (14.2%) amateur. Studies were cross-sectional (46%), retrospective (30%), or prospective (23%). Four studies (29%) included neck-strengthening interventions. **Discussion:** Forwards were significantly stronger than backs in all neck strength measures and were stronger in extension than any other movement direction. Professional senior players were stronger in all strength measures than any other age or level of competition ($p < 0.05$). Isometric exercise routines in semi-professional and professional players were shown to improve neck strength in all directions. In Rugby Union, strengthening

the neck effectively reduced neck match-related injuries. **Take Home Message:** It is important to implement evidence-based neck training strategies to minimise neck and head injury risk in Rugby Union.

54. The working conditions of performance analysts in Oceania

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Introduction: Performance analysis (PA) has become an essential tool in the sports industry. Current PA research has been completed mainly looking at the application and effectiveness in different sport settings. Despite the continued growth of research on PA there is little known about the working condition of the analysts. Working conditions studies are completed to gain an understanding of the work environment and identify ways to better support practitioners. This research aims to explore the working conditions of the performance analysts. **Method:** An online survey distributed to performance analysts in Oceania collected data on PA demographics, job type, remuneration and job satisfaction. Data analysis involved descriptive statistics, a T-test and a Mann Whitney U. **Results:** The 65 performance analysts in this study are predominantly 25-34-year-old males on \$62,000 per annum, with six years of experience. The majority of the participants held a Bachelor's degree or higher qualification and frequently travelled and worked above their agreed hours unpaid. **Discussion:** The work demands of a performance analyst could lead to burnout as found in other industries where employees were stressed and working long hours. **Take home message:** Work demands should be managed before they become a bigger issue with burnout and poor retention of employees a possibility, like in the coaching industry.

55. Beat the heat: The effectiveness of a practical, cold water arm immersion protocol during a simulated rugby sevens protocol.

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Background: The environmental conditions at the Tokyo 2020 Olympics are likely to decrease performance factors associated with rugby sevens. The efficacy of many cooling strategies has been well described, however, practical strategies such as pre- and per-cooling using cold-water immersion of the arms (CWI) has received little consideration. **Methods:** Nine recreationally trained athletes (4 male) completed two Wattbike™ repeated-sprint interventions using a cross-over design in a heated laboratory environment (~30-32 °C, ~50-65% rH). The protocol was designed to replicate the physiological demands of rugby sevens. Tympanic temperature (T_{TYMP}), peak power (PP), and thermal comfort was collected before, during, and after each intervention. Participants either performed CWAI with arms

submerged to the elbow in ice water for 60 seconds both after the warm up and during half-time, or a passive control. **Results:** CWI enhanced PP immediately post half-time by 96 W (p=0.01, Cohen's d=0.61), with no significant differences in PP at any other time point. CWI decreased T_{TYMP} at all time points after half-time (p<0.05; d=1.07 to 1.19). Thermal comfort was significantly improved immediately post each immersion (p<0.05). **Discussion:** Given that the CWI intervention was transiently effective in enhancing PP and thermal comfort, and decreasing T_{TYMP}, it may provide a practical pre- &/or per-cooling strategy for athletes competing in hot environments. Effective cooling may also positively impact subsequent rugby sevens performance by mitigating the increase in T_{TYMP}. **Take home message:** A cold-water arm immersion protocol can improve performance, T_{TYMP}, and perceptual measures when completing repeated efforts in the heat.

56. Comparative running demands of under 18, under 21 and senior regional field hockey tournaments

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Introduction: The purpose of this study was to quantify match play running demands of field hockey players in relation to playing level and position. **Methods:** Distance covered was measured on 30 regional field hockey players (under 18, under 21 and senior) during 18 open and age-group national competition tournament games. Total distance (TD), high-intensity running (HIR; distance ≥15km.hr), low-intensity running (LIR; distance ≤14.9km.hr), high-intensity acceleration (HI-ACC; acceleration ≥3m.s⁻²) and high-intensity deceleration (HI-DEC; deceleration ≥3m.s⁻²) were assessed global positioning system (GPS) technology. Data was analysed using analysis of variance (ANOVA) and post hoc Bonferroni correction (p ≤ 0.05). **Results:** Under 18 strikers (1839.79 ± 456.85) and midfielders (1501.56 ± 559.42) showcased significantly higher HIR distance than the under 21 strikers (1211.08 ± 458.49) and midfielders (1064.00 ± 432.69) respectively. Senior midfielders (5961.55 ± 964.05) covered significantly higher LIR distance in comparison to both under 18 (5046.91 ± 852.14) and 21 midfielders (5126.83 ± 376.24), more HI-ACC efforts (194.61 ± 31.11) than under 21 midfielders (164.94 ± 21.64) and more HI-DEC efforts (73.12 ± 18.45) than under 18 midfielders (55.21 ± 13.42). Under 18 strikers showcased significantly less HI-ACC efforts (137.88 ± 19.17) than senior (168.11 ± 25.16) and under 21 strikers (173.25 ± 18.29) and less HI-DEC efforts (61.21 ± 12.17) than the under 21 strikers (82.50 ± 21.01). Senior defenders had significantly more HI-ACC efforts (169.35 ± 38.56) than under 18 defenders (140.45 ± 33.39). **Take home message:** These results show that the different playing levels and positions in field hockey are sufficiently different to warrant specialized, position-specific, conditioning training as part of an informed long-term athletic development plan.

57. Effects of high-intensity interval training on body composition markers in obese prepubescent children: A narrative review

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Introduction: Childhood obesity is a worldwide epidemic affecting over 41 million children. Exercise intensity is a training variable used to enhance body composition. Beyond body weight, body mass index (BMI), fat mass, fat free mass (FFM), waist circumference, skinfold thickness and body fat percentages are various markers of body composition and are frequently used to report on the health of individuals. Research on the most effective training intensity for improved body composition in obese children is limited. **Methods:** Articles were selected through EBSCO host database and Google Scholar using search terms including; cardiovascular exercise, body composition AND children (5-12 years). The search criteria was specified to recent articles and medium-term interventions. Five articles were included in the present study. The intensities examined were low-intensity continuous training (LICT), moderate-intensity continuous training (MICT), high-intensity interval training (HIIT), and super-maximal intensity training (SMIT). **Results:** Although body weight changes were negligible, most training intensities showed reductions in BMI (LICT effect size (ES)=0.24, MICT ES=0.22 and ES=1.52, and HIIT ES=0.65). HIIT and MICT both resulted in moderate increases in FFM (ES=0.57 and 0.55, respectively). Most training intensities showed decreases in waist circumference (LICT ES=0.62, MICT ES=0.42, HIIT ES=0.32). SMIT reported a large reduction in skinfold measurements (ES=1.08) and most training intensities reported reductions in body fat percentage (LICT ES=0.24, MICT ES=0.22 and ES=0.72, HIIT ES=0.22). **Discussion:** The results seem to show no superior method between the training intensities but suggested that exercise at any intensity was better for body composition markers than no exercise. **Take home message:** While changes in body composition are small during moderate-term interventions, exercise practitioners working with obese children can still see benefits in other body composition markers, regardless of the exercise intensity.

58. The effect of lower body strength training programmes on vertical jump height in dancers: a meta-analysis

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Introduction: Dance is an activity which requires a combination of strength and power to jump high with precision. Dance teachers, and their strength and conditioning trainers, would benefit from understanding the relationship between lower body strength training and vertical jump height. By implementing alternative training, such as weight and plyometric training, they could significantly improve jumping capacity and subsequently dance performance. **Methods:** An online search was conducted using EBSCO-Host databases and Google Scholar, using the keywords: “dance and vertical jump”

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and “strength and vertical jump”. From the original 120 articles, the 5 most relevant to the research question were selected. Effect Sizes (ES) were calculated for each study using “Hedges’ “g” to give a standard comparison of variables of interest across the 5 studies. **Results:** All 5 studies showed that lower body strength and power training of 6-12 weeks increased vertical jump height (Mean ES = 0.47 moderate), compared to groups who received no training. **Discussion:** Weight training increases jump height, but plyometric training mimics the same movement pattern used in dance. Therefore an overall strength and conditioning programme should also be included to minimise the occurrence of tedium during training and reduce injuries. Dancing usually involves more than one maximal vertical jump, so further research should focus on testing repetitive jumping. **Take Home Message:** Strength training, including plyometric training, is beneficial to increasing jump height in dancers which should correlate with improved execution of precision dance movements and should therefore be included in their strength and conditioning training programmes.

59. Stability of heart rate at lactate threshold between temperate and heat stress environments

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Introduction: Many endurance athletes perform specific blocks of training in hot environments in ‘heat stress training camps’. It is not known if lactate threshold heart rates measured in temperate conditions are reflective of those under moderate environmental heat stress. **Method:** Sixteen endurance-trained cyclists and triathletes performed incremental exercise assessments in 18 and 35°C to determine heart rates at specific absolute lactate thresholds. **Results:** Heart rate at lactate thresholds defined as the initial rise in blood lactate concentration of 1 mmol.L⁻¹ above baseline and fixed blood lactate concentrations of 2, 3, and 4 mmol.L⁻¹ were not significantly different between-environments (P > 0.13). The within-subject coefficients of variation for heart rate at these lactate thresholds between-conditions was low (2.4-4.5 %), with significant strong positive correlations between measurements in the two environments (r = 0.90-0.95, P < 0.05). **Discussion:** These data indicate that heart rate measurements at absolute lactate thresholds in temperate environments are reflective of measurements taken under moderate environmental heat stress. **Take home message:** Endurance athletes embarking on heat stress training camps can use heart rate-based thresholds ascertained in temperate environments to prescribe training under moderate environmental heat stress.

60. Survey of eccentric-based strength and conditioning practices in sport

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Introduction: Eccentric-based training (ECC) research suggests that neuromuscular factors contributing to eccentric force production and subsequent adaptation may be of interest to strength and conditioning practitioners. This study investigated the real world ECC practices in sport. **Method:** 224 practitioners were electronically surveyed anonymously with 98 responses available for analysis. **Results:** Respondents were predominantly 25 to 34 years old (56%) working globally (USA, 30%; NZ, 25%; AU, 10%; UK, 8%). Fifty-seven percent had completed a Master's degree and 22% indicated "Academic journal" as their most common source of ECC information. Sport Performance (64%), Injury Prevention (24%), and Rehabilitation (8%) were the most common reasons to include ECC. Respondents programmed ECC for Strength (35%), Hypertrophy (19%), Power (18%), and Speed (14%). A majority of respondents did not monitor ECC load (58%) or use eccentric-specific testing (75%). 16 respondents commented that DOMS and high-intensity activities were actively avoided. ECC intensity was prescribed as % of 1RM (34%), RPE (20%) or Velocity (16%). **Discussion:** ECC is common among practitioners working with athletes. Respondents indicated muscle soreness and concurrent high-intensity activities were concerns during ECC but reported not using eccentric monitoring or testing. A greater understanding of eccentric contribution to sport performance and injury prevention may help define testing and monitoring protocols for the prescription of ECC interventions. **Take home message:** Practitioners should consider factors such as periodisation, soreness, and athlete monitoring when designing ECC programs. The findings of this survey indicate that no uniform strategies exist for the prescription of ECC among experienced practitioners.

61. Effects of arousal and valence to odors on autonomic activities and physiological parameters

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Introduction: Certain odors can affect autonomic nerve system and physiological parameters due to smell-induced activity in the limbic system. This study was designed to investigate the influence of odor, taking the level of arousal and valence into account, on autonomic nerve activities and physiological parameters. **Methods:** Eight healthy young males (20.1 ± 0.8 yr), who gave a response of high arousal and negative valence to the odor of vinegar (VING), and an opposite response to the odor of orange (OREG), were selected as subjects. Heart rate and its variability, blood pressure (BP), and salivary amylase were evaluated before and after smelling odors (OREG, VING, and no odor) for the subjects who were quietly seated. A no odor condition was used as a control. **Results:** Repeated measures

ANOVA with a Tukey post-hoc test revealed a significant odor effect in the variables of HRV, and BP. The change in the LF/HF ratio for VING was significantly greater than that for the control ($p < 0.05$), and the HF norm change ratio was also significantly lower for VING than the control ($p < 0.05$). VING also had significantly higher diastolic and mean BP than OREG ($p < 0.05$). Contrary to our expectation, the odor effect on salivary amylase did not reach the level of significance. **Discussion:** Due to combined effect of high arousal and valence levels of VING odor enhanced sympathetic nerve activity and lowered parasympathetic nerve activity. **Take home message:** Based on the findings, it can be concluded that some emotionally linked odors were strong enough to modulate autonomic nerve activities as well as the level of BP in resting individuals.

62. Individual responses to acute manipulation of muscle glycogen on high-intensity performance and running economy

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Introduction: Intentionally training with low muscle glycogen is associated with improved muscle oxidative capacity. We examined the acute effects of low muscle glycogen on exercise performance, running economy (RE) and substrate metabolism. **Methods:** On two occasions, nine male runners ($\dot{V}O_{2peak}$ 60.3 ± 3.3 mL.kg⁻¹.min⁻¹) completed a glycogen depletion protocol (90mins at 75% $v\dot{V}O_{2peak}$ followed by 10 x 1min at 110% $v\dot{V}O_{2peak}$) on day 1. This was followed by high (HIGH) or low (LOW) carbohydrate intake (> 10 g.kg⁻¹.day⁻¹ and < 50 g.day⁻¹, respectively) until completion of a performance protocol on day 2 consisting of a series of time-trials (TT) (50m to 3000m) and assessment of RE and substrate utilization, completed as a separate test before the time-trial tests. **Results:** Glycogen depletion followed by LOW significantly increased fat oxidation by 0.26 ± 0.24 g.min⁻¹ ($P=0.011$) at 14 km.h⁻¹ and 0.36 ± 0.15 g.min⁻¹ at 16 km.h⁻¹ ($P<0.001$). There were no differences between LOW and HIGH for any TT distance ($P>0.05$) though some athletes performed better in LOW ($n=5$). Mean TT performance times for LOW and HIGH were as follows: 3000m TT 651.7 ± 52.8 s and 646.4 ± 52.5 s, 1500m TT 304.0 ± 20.2 s and 304.2 ± 22.1 s, 400m TT 67.64 ± 4.2 s and 67.3 ± 3.8 s, 50m TT 7.27 ± 0.44 s and 7.25 ± 0.45 s. Running economy did not differ between conditions ($P>0.05$), though positive correlations existed between RE and change (%) in TT performance (Spearman $r=0.48$ for 3000m TT, $r=0.33$ for 1500m TT and $r=0.30$ for 400m TT). **Take home message:** Acute manipulation of muscle glycogen did not affect high-intensity running performance across a range of distances, though individual responses to performance trials in LOW and HIGH were observed. Individual responses should be considered when prescribing high-intensity training with intentional reductions in muscle glycogen.

63. The multidisciplinary process leading to return from underperformance and sustainable success in the world's best cross-country skier

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Introduction: Despite 20-60% of elite endurance athletes experience overtraining syndrome at some point of their career, there is a lack of studies investigating the multidisciplinary factors of elite athletes who successfully recover from overtraining. In a recent study, we investigated the longitudinal training characteristics of the world's best female cross-country (XC) skier. After being the world's highest ranked XC-skier, the athlete experienced a critical period in her career with stagnation and decline in performance. However, she managed to turn this situation around, returning to high-level performance and sustaining this throughout her career. Therefore, the aim of this case-study is to investigate the factors associated with underperformance, and the subsequent changes in training characteristics and supportive actions when returning to sustainable success as the world's best XC-skier. **Methods:** The participant is the most-decorated winter Olympian, with 8 Olympic gold medals and 18 World Championship titles. Training data was categorised by training form (endurance, strength, and speed), intensity [low (LIT), moderate (MIT) and high (HIT)], and mode (running, cycling, and skiing/roller skiing). In addition, test data were retrospectively analysed and interviews were performed with the participant and her support team. **Results:** After the competitive season, the participant had 8 weeks without systematic training, and an evaluation process aiming to detect the factors contributing to underperformance. Here physiological, technical and psychological challenges were detected. As a consequence, the participant included less HIT, more MIT and more LIT during the general preparation phase, but with similar total endurance training load as previous season. Additionally, more strength training and new ski-specific strength exercises were included. Finally, the athlete's autonomy when planning and adjusting training was increased, non-training stressors were reduced, more frequent testing was included, systematic mental training was initiated, her nutritional strategy was adjusted and her asthma treatment optimised. **Take home message:** Overall, the current case-study could be used as a framework for the holistic approach to treating an overtraining condition and for generation of new hypothesis in this exiting area.

64. The effects of hypohydration and menstrual cycle phase on pain perception

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Introduction: Multiple factors can contribute to an individual's perception of pain. Hypohydration has recently been shown to increase pain levels in men. However, this finding is yet too be explored in women, whose pain perception may also be influenced by menstrual cycle phase. This study investigated the effects of hypohydration (via 24h of fluid restriction) on pain perception across the menstrual cycle. We also examined acute water ingestion as a countermeasure. **Methods:** Twelve healthy women (age: 27 ± 7 years) with regular menstrual cycles (26-31 days) were studied twice during each menstrual cycle phase (early-follicular and mid-luteal), while either euhydrated or hypohydrated. Ischaemic pain was induced in the forearm twice, before and 30 minutes after water ingestion (5ml·kg⁻¹). **Results:** Hypohydration (USG: 1.024 ± 0.005 , sOsm: 306 ± 7 Osm/kg) increased ischaemic pain ratings ($P=0.01$) and reduced pain tolerance ($P=0.05$) compared to euhydration (USG: 1.012 ± 0.009 , sOsm: 294 ± 11 Osm/kg). Menstrual cycle phase did not affect pain perception, nor did it modulate the effects of hypohydration on pain. Water ingestion had no effect on pain perception. **Discussion:** Mild hypohydration (<1% body mass loss) increased measures of ischaemic pain in healthy eumenorrhoeic women, whereas menstrual cycle phase had no influence on pain. Drinking a bolus of water did not acutely reduce the pro-nociceptive effects of hypohydration. **Take home message:** Ingesting sufficient amounts of fluids throughout the day to prevent dehydration can help women decrease their perception of pain. Future research on pain in humans should measure hydration status to remove possible confounding effects.

65. Water Safe Waikato: Improving international students' water safety skills

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Introduction: Analysis of drowning incidence data indicates that international students are a high risk group within the New Zealand population. In the last year, the University of Waikato undertook to develop and deliver a newly developed, evidence based water safety program ("Water Safe Waikato") to enable international students to enjoy the water safely in New Zealand. The program was delivered to 90 students on a trial basis at the University of Waikato. Here, we present an assessment of the program and the effects it had on participants' knowledge, skills, behaviours and attitudes related to water safety. **Method:** Assessment included pre- and post-program evaluation of attitudes, behaviours, and knowledge of water safety topics (questionnaire data). Separately, we measured the effects of a single in-water learning session on movement execution (video based expert ratings pre and post session) and self-efficacy (self-report pre and post session) regarding the skills of floating and water treading. **Results:** Participants ($n = 28$ after removing incomplete surveys) significantly improved their water skills confidence ($t(27) = -3.658$ $p < .01$), confidence in supervising

others ($t(27) = -6.483$, $p < .01$) and water safety knowledge ($t(27) = -6.625$, $p < .01$), between pre- and post-program tests. No significant change was found in their water-related anxiety ($t(27) = 1.495$, $p = .146$). The effects of the in-water session are being analyzed currently. **Discussion:** Participants' knowledge about water safety, their confidence in their own water safety skills and their ability to supervise others around the water improved as a result of attending the program. This suggests that the developed program can be used to improve the overall water safety awareness and skills of large groups of international students. A detailed review and evaluation of the individual course delivery components will help in making decisions with respect to large scale delivery of the program. **Take Home Message:** The specifically developed program "Water Safe Waikato" may, upon some adaptation, be used to improve the overall water safety awareness and skills of large groups of international students in New Zealand.

66. Exercise and Insulin-like Growth Factor (IGF-1): A Systematic Review & Meta-Analysis

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Introduction: Insulin-like growth factor-1 concentration [IGF-1] is associated with multiple physiologic outcomes including increased muscle growth and repair and increased cancer risk. Exercise has been observed to influence circulating [IGF-1]. However, effects of exercise on [IGF-1] are inconsistent. **Aim:**

To conduct a systematic review and meta-analysis to determine the relationship between [IGF-1] and exercise. **Methods:** Searches of Scopus, PubMed, Sport Discus, Web of Science, and Academic Search Complete databases up to September, 2017 retrieved 4,006 publications, which were subsequently screened. Eighty-five studies met the inclusion criteria and were included in the meta-analysis. Separate analyses were performed for studies that sampled total [IGF-1] before and after exercise without a control group ($n=71$) and studies that utilized a control group ($n=14$). **Results:** When compared to resting [IGF-1] before exercise, exercise interventions without a control group resulted in increases of [IGF-1] (Cohen's $d=0.276$, 95% CI 0.181 to 0.371, $I^2=73.2\%$). Subgroup analysis revealed type of exercise ($p<0.001$) was a source of heterogeneity, with exercise performed with blood flow restriction, endurance exercise, and ultra-endurance racing reducing [IGF-1], while resistance, sprint, and resistance with sprint exercise increasing [IGF-1]. When exercise was compared to a non-exercise control exercise was found to induce a small increase in [IGF-1] (Cohen's $d=0.351$, 95% CI 0.043 to 0.659, $I^2=83.9\%$). Again, exercise type was found to be a source of heterogeneity with endurance and sprint exercise producing small reductions in [IGF-1], while resistance exercise and blood flow restriction produced a small to large increase in [IGF-1]. **Conclusions:** This is the first meta-analysis investigating the effects of exercise on [IGF-1]. The nature of the response is largely determined by type of exercise. Resistance exercise increases [IGF-1] while endurance exercise decreases [IGF-1]. Therefore, based upon the acute [IGF-1] response, it is speculated that endurance exercise may be more beneficial for those with increased risk of cancer and resistance exercise for those wanting to maximize muscle gain.