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SEONZ

SPORT & EXERCISE SCIENCE

— NEW ZEALAND —

Sport and Exercise Science New Zealand

Annual Conference, 25-27 November 2020

University of Canterbury, Christchurch

Hosted by the School of Health Sciences at the University of Canterbury



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Contents

Welcome.....	3
Programme	4
Sponsors	9
SESNZ Membership Benefit.....	12
Keynote Speakers	13
Invited Speaker	15
SOBI: Concussion Panel	18
Workshops.....	19
Oral Presentations.....	20
Strength and Conditioning.....	20
Performance Analysis.....	25
Biomechanics.....	25
Exercise Physiology	27
Injury Preventions.....	29
Health & Sports Medicine	30
Coaching.....	32
Sport Psychology.....	33
Sport Science	20
Poster Presentations.....	36

Welcome

Welcome to the 2020 Sport and Exercise Science New Zealand Annual Conference at the University of Canterbury! Having held last year's conference at Massey University, we make a return to the South Island this year and we are delighted that the team at the University of Canterbury agreed to host this year's conference. We very much look forward to catching up with you at the conference over the next three days. Don't forget to join us for a drink and pizza at our social event at the Kaiser Brew Garden (**Upstairs at Riverside Market.**, Cnr Lichfield St and Oxford Tce, Christchurch) tomorrow evening (Thursday 26th November) if you are free, from 6.30pm onwards.

As part of our continued work to develop links with strategic partners we are very fortunate, and delighted to welcome to the Board, Professor Stafford Murray from High Performance Sport New Zealand and Stacey Pine, a talented AEP practitioner working in New Zealand. Stacey and Stafford bring a wealth of experience to support the work of SESNZ and great that their foci are in the areas of exercise and sport, respectively. Thank you Stacey and Stafford for taking the time to join us!

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 three days. It is exciting to see the growth in attendance to the conference being made year on year and this year's growth, which is exceptional in the current Covid-19 situation, 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 Saturday afternoon. A big thank you also goes to our sponsors and helpers who include VXSport: gbc Biomed, XLR8, Australian Catholic University, Human Kinetics and, our gratitude to all at the University of Canterbury who have helped make this conference happen.

As a note for next year, we are very pleased to confirm that the 2021 SESNZ Conference will be held at AUT, Auckland. Thank you very much to Professor Andy Kilding and the team at AUT for agreeing to be our hosts in 2021, and we look forward to gathering in Auckland next year. If you and your University would be interested to host the 2022 or 2023 Conferences please let anyone of the Board members know.

It is always a team effort to make a conference run, so thank you to everyone involved at the University of Canterbury, especially Jessica Allan, our Operations Manager and Violet Lawson, 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

SESNZ Conference
25th-27th November 2020
University of Canterbury, Christchurch

Day One: Wednesday 25th November - Evening

15:30 Registration & Refreshments

17:00-18:00

Keynote Speaker: Scott Robertson and Simon Thomas
Crusaders, The Art and Science of Coaching
Chair: Professor Rich Masters

08:00 Registration & Refreshments

08:15 **Mihi whakatau**
Te Hurinui Clarke & Professor Letita Fickel (Pro Vice-Chancellor) University of Canterbury

08:30 **gbc Biomed - Gold Sponsor**

08.35-09:35 **Keynote Speaker: Professor Thor Besier**
University of Auckland, *Wearing Sensors in Biomechanics*
Chair: Associate Professor Mel Bussey

Parallel Sessions	K1 Lecture Theatre Theme: Rugby Chair: Professor Andrew Kilding	Sport Science Laboratory Theme: Environmental Physiology Chair: Professor Jim Cotter	Strength & Conditioning Laboratory Theme: Weightlifting Chair: Mark Drury
09:35	Running demands in women's rugby. <i>Alice Busbridge</i>	Effect of altitude training on basketball performance. <i>Hoani Smith</i>	<i>John Wilson</i>
09:50	The impact of small-sided conditioning games on rugby union youth. <i>Koen Wintershoven</i>	Regulation of brain oxygen delivery in hypoxia: the effect of acclimatization <i>Travis Gibbons</i>	
10:05	Eccentric force-load-velocity characteristics and relationships with performance measures in trained rugby union athletes. <i>Conor McNeil</i>	Cold-water immersion of the arms as a cooling strategy during repeated sprint exercise. <i>Stephen Fenemor</i>	Olympic Lifting Masterclass <i>John Wilson</i>
10:20	Benchmarking calf muscle power and endurance in rugby athletes using the Calf Raise app. <i>Kim Hébert-Losier</i>	Comparing the effectiveness of 9-day passive vs. active heat acclimation. <i>Jamie Prout</i>	

10:35-11:00 **Morning Tea**

Parallel Sessions	K1 Lecture Theatre Theme: Performance and Coaching Development Chair: Professor Chris Button	Sport Science Laboratory Theme: Chair: Professor Nick Draper	Strength & Conditioning Laboratory Theme: Biomechanics Chair: Associate Professor Mike Hamlin
11:00	An evaluation of data sources in netball performance analysis. <i>Hayden Croft</i>	AEP Panel Discussion	Load carriage. <i>SGT Kyle Foster</i>
11:15	Community rugby coaches' perceptions and practices related to Small Blacks education programme and tools package: what are the barriers and facilitators to programme implementation? <i>Eamon Reily</i>		
11:30	Considerations in developing adaptable and skilful athletes <i>Chris Button</i>		Neck posterior chain considerations for pilots. <i>Devon Scott</i>
11:45	Energetic and cognitive demands of different water treading patterns. <i>Tina van Duijn</i>		

12:00 **VXSports - Platinum Sponsor**

12:05-12:45 **Invited Speaker: Stephen Hotter**
High Performance Sport NZ, *Silver Ferns Gold Medal Journey to the Netball World Cup 2019*
Chair: Professor Stafford Murray

12:45-14:00 **Lunch & Poster Presentations**

2020 SESNZ Annual Conference

Day Two: Thursday 26th November - Afternoon

12:45-14:00

Lunch & Poster Presentations

Parallel Sessions	K1 Lecture Theatre Theme: Psychology Chair: Associate Professor Elaine Hargreaves	Sport Science Laboratory Theme: Health Chair: Dr Kate Thomas	Strength & Conditioning Laboratory Themes: Running and Biomechanics Chair: Associate Professor Toby Mundel
14:00	Rugby Fans in Training New Zealand (RuFIT-NZ): a randomised controlled trial of a healthy lifestyle program for overweight men delivered through professional rugby clubs in New Zealand. <i>Elaine Hargreaves</i>	Physical activity and mental health during COVID-19 lockdown: an international comparison. <i>Catherine Elliot</i>	Determining the role of exercise-induced heat and upper limb sprint interval training on metabolic function. <i>Ashton Tourell</i>
14:15	Influence of perceived opposition ability on exerted effort in junior footballers. <i>Atticus Foulcher</i>	Using a motor analogy to promote safe-landing from unexpected falls. <i>Sana Oladi</i>	The influence of ankle dorsiflexion range of motion on unanticipated cutting kinematics. <i>Ivana Hanzlíková</i>
14:30	Impact of COVID-19 Lockdown on the mental health of New Zealand tertiary students who participate in regular physical activity. <i>Nora-Anne Kwok</i>	The effect of passive heat therapy on body composition and isometric muscle strength in patients with severe lower-limb osteoarthritis. <i>Brendon Roxburgh</i>	Examining footwear manufacturer websites – Is the industry ahead of science? <i>Codi Ramsey</i>
14:45	Investigating the effect of colour during football penalty kicks: retrospective analysis of professional football players. <i>So Hyun Park</i>	The influence of COVID-19 Lockdown restrictions on perceived nutrition & training habits in rugby union players. <i>Charlie Roberts</i>	On-field movements, heart rate responses and perceived exertion of lead referees in Rugby World Cup matches, 2019 <i>Matthew Blair</i>
15:00	Elite hockey performance: Examining the relationship between propensity for reinvestment and challenge and threat state. <i>Merel Hoskens</i>	Expanding the RED-S model: a mixed-methods approach to elite male and female track cyclists with varying levels of energy availability. <i>Katie Schofield</i>	Football small-sided games and sprint demands: Can we push the boundaries? <i>Daniel Gordon</i>
15:15	Response inhibition under physical and emotional stress. <i>Arne Nieuwenhuys</i>	Clarifying the role of the strength and conditioning coach in athlete rehabilitation <i>Andrew Armstrong</i>	Loading and structural performance of tandem bicycle frames. <i>Digby Symons</i>

15:30-16:00

Afternoon Tea

Parallel Sessions	K1 Lecture Theatre Theme: Rugby Chair: Professor Andrew Kilding	Sport Science Laboratory Theme: Cricket Chair: Dr Sibi Walters	Strength & Conditioning Laboratory Theme: Sports Performance Chair:
16:00		Are there any differences in the shoulder muscle strength and range of motion between cricket fast bowlers with and without shoulder pain? <i>Sibi Walters</i>	
16:15	Invited Speaker: Simon Jones High Performance Sport New Zealand <i>Japan Rugby preparation for Rugby World Cup.</i>	Accumulated player load in fast bowlers across maximal and submaximal intensities; comparison of upper back and non-bowling wrist IMUs. <i>Corey Perrett</i>	
16:30		The relationship between release speed, heart rate and RPE across maximal and submaximal intensities in fast bowlers. <i>Corey Perrett</i>	
16:45			

Keynote Speaker: Professor Patria Hume

17:00-18:00

Auckland University of Technology, (SOBI) *Sports Originated Brain Injury*

Chair: Associate Professor Mel Bussey

18:30 Evening Social Function - Kaiser Brew Garden
Riverside Terrace (upstairs), 96 Oxford Terrace

2020 SESNZ Annual Conference
Day Three: Friday 27th November

08:30 Registration & Refreshments

09:00 VXSport - Platinum Sponsor

09:05-10:05

Keynote Speaker: Professor Jim Cotter
University of Otago, *Exercise Fit for the Environment*
Chair: Associate Professor Toby Mundel

10:05-10:30

Morning Tea

Parallel Sessions	K1 Lecture Theatre Theme: Rugby Concussion Chair: Professor Patria Hume	Sport Science Laboratory Theme: Sport Science in the Defence Force Chair: Associate Professor Toby Mundel	Strength & Conditioning Laboratory Theme: S&C Chair: Mark Drury
10:30	SOBI Symposium Speakers: Mel Bussy, Joshua McGeown, Nick Draper, Ken Quarrie		Developing a successful S&C environment. <i>Simon Thomas</i>
11:30	Debate: Should contact sports be limited for children under 12 years to reduce sport originated brain injury?	Discussion on the benefits of utilising human performance specialists in the NZDF. <i>LT COL Phil Wright</i>	S&C Workshop The science and practice of eccentric training. <i>Angus Ross</i>
11:45	Laboratory validation of instrumented mouthguard for head impact measurement in sport. <i>Danyon Stitt</i>	Pack carriage and shoulder injuries. <i>MAJ (Dr) Jacques Rousseau</i>	
12:00	The use of Steady-State Visual Evoked Potentials (SSVEPs) in concussion diagnosis and recovery assessment. <i>Jen Treacy</i>	Longer sleep duration enhances training adaptations in a military population. <i>Captain Dave Edgar</i>	
12:15	Exploring head control during impact perturbations in rugby players with history of concussion. <i>Melanie Bussey</i>	Lower limb injury prevention in the New Zealand Army. <i>MAJ (Dr) Jacques Rousseau</i>	

12:30-13:30

Lunch & AGM

13:30- 14:30

Keynote Speaker: Professor Rich Masters,
University of Waikato, *Recruiting the Cognitive Unconscious for Better Performance in Sport*
Chair: Professor Nick Draper

14:30

Closing



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Most New Zealand sports science laboratories have equipment that gbcBioMed has supplied and supported, along with private clinics, high performance centres, and hospitals. Martin Little, our Service Engineer and I have had the privilege of visiting most of the labs in NZ, some in Australia and other countries. This year we have recruited a new staff member to help bring more high-quality products and further support gbcBioMed in its mission. Philip Shambrook has a strong technical engineering background and has recently completed a PhD at La Trobe University in Australia. Together, Martin, Philip and I will further grow gbcBioMed's expertise in its current product range whilst exploring new markets and developing new products.

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

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The Faculty of Health Science is deeply engaged with industry, government, and the community. Our curricula are developed and refined in conjunction with industry leaders to ensure they reflect local and international knowledge, rapid changes in the health environment, and advances in student learning.

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SESNZ

SPORT & EXERCISE SCIENCE

— NEW ZEALAND —

SESNZ are able to offer discounted insurance to our members through GSI Direct. Members can access this through the following link (n.b. not available through GSI Direct's website)

The insurance is for \$230 (incl GST) for:

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SESNZ members can purchase insurance cover directly through the following link

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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.



If you aren't already a SESNZ member follow this link to join us and grow your network:

<https://sesnz.org.nz/membership/>

Annual membership for 2020 is only \$120 for Full Members and \$30 for Students.

Keynote Speakers

Professor Patria Hume

Professor Patria Hume is a leader in the field of sport sciences, and a pioneer in science and technology for sport. She has an international reputation for research aimed at improving sport technique and reducing sports injuries using sports biomechanics, anthropometry and epidemiology.



Her “Sport Risk Factors” research platform focuses on problem extent (e.g. sports injuries), injury mechanisms (e.g. concussion, lower limb injury), development/evaluation of injury prevention strategies (i.e. ACC SportSmart) and monitoring (e.g. physique assessment). In 2016, she gained the most prestigious award in her field – the International Society of Biomechanics in Sports (ISBS) Geoffrey Dyson Award.

Patria led the World Rugby project on long term player health outcomes including the effects of concussion, and on player protective equipment and prosthetic devices and hearing aid development for rugby.

Patria was a NZ Herald New Zealander of 2016 Finalist in recognition of the impact of her research work on concussion in rugby. Patria was the 2016 recipient of AUT’s University Medal, for her dedication to, and sustained record in, producing high impact research, and her commitment to developing the next generation of sports biomechanics researchers.

Patria was appointed by Her Excellency the Governor-General to the Drug Free Sport New Zealand Board, Manatū Taonga Ministry for Culture and Heritage, from 20 Jan 2020.

Professor Rich Masters

Rich Masters is Professor of Human Movement Psychology in the School of Health, Sport and Human Performance at the University of Waikato and a Visiting Professor in the School of Public Health at the University of Hong Kong. He is Editor-in-Chief of the *Journal of Sport and Exercise Science*.



Prior to joining the University of Waikato in 2014, Rich was Director of the Institute of Human Performance at the University of Hong Kong. Before that, he lectured in the School of Sport and Exercise Sciences at the University of Birmingham, England. Rich holds a First Class Honours degree and a Master’s degree in Psychology from the University of Otago as well as a D.Phil in Experimental Psychology from the University of York, England. He held a Universitas 21 Fellowship in 2005, gave the Dr Tom Anderson Memorial Lecture in Sport and Exercise Science

in 2006, and has received numerous Distinguished Scholar Awards from prestigious institutions, such as University College Dublin. He sat on the Health Panel for the NZ Performance-Based Research Fund (PBRF 2018) Quality Evaluation. Rich is interested in the psychology of human performance and is well known for his work in implicit (unconscious) motor learning. He has received in excess of NZD5M in grant funding for his research, which has been published extensively in disciplines that include the sport and exercise sciences, psychology, rehabilitation sciences, geriatrics, neuroscience, dentistry, speech sciences and surgery.

Professor Thor Besier

Thor is a Professor at the Auckland Bioengineering Institute and has a joint appointment with the Department of Engineering Science at the University of Auckland. He completed his PhD in musculoskeletal biomechanics at The University of Western Australia in 2000 and was a postdoctoral fellow in the Bioengineering Department at Stanford University from 2003 to 2006. Thor established Stanford’s Human Performance Laboratory and was a faculty member in the Department of Orthopaedics at Stanford from 2006 to 2010, before returning home to New Zealand in 2011.



Thor’s research combines medical imaging with computational modelling to understand mechanisms of musculoskeletal injury and disease. Current projects include the development of gait retraining technology and population modelling to test orthopaedic implants. He has published >100 scientific articles on these topics and has received grant funding from the NZ Marsden Fund and MBIE, the US Food & Drug Administration (FDA), the US National Institutes of Health (NIH), Australian Research Council and the Australian National Health & Medical Research Council. Thor has spun-out two companies from his research, including *IMeasureU* (inertial sensing for human movement) and *FormusLabs* (orthopaedic pre-operative planning).

Professor Jim Cotter

Jim is a Professor of Exercise and Environmental Physiology at the University of Otago. He never managed to separate those subjects, having grown up in the backblocks of the West Coast before studying Physical Education and Physiology throughout undergrad (Canterbury & Otago; midst of 20th Century), Masters (Otago) and PhD (Wollongong). His research interests are – unintentionally – in the extremes of time (SIT to Ultra-endurance), space,



human capacity and stress (mode and extent). He focuses mainly on cardiovascular, cerebrovascular, thermoregulatory and functional effects of exercise and environmental stress – in contexts of health, disease and performance.

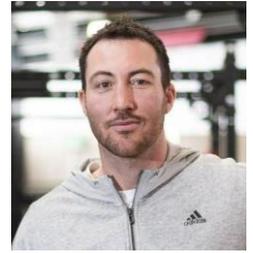
Scott Robertson and Simon Thomas – Co-Presentation

Scott Robertson is the Head Coach of the BNZ Crusaders. He played professionally from 1998 – 2007, including 4 years as an All Black during which he played 23 international matches. He began coaching in 2004 before moving to France and then Japan as a professional player. When he



returned in 2008 he started focusing on his coaching career, in 2017 he came into his current position as the BNZ Crusaders Head Coach.

Simon Thomas has been the BNZ Crusaders Head of Physical Performance since 2016; he has been with the team since 2010. He has worked as a Strength and Conditioning coach for various Rugby Union teams since completing his Bachelor of Sport and Recreation in 2008. During his career he has also worked as an Exercise Prescription Lecturer at Auckland University of Technology and as a Regional Physical Performance Specialist with High Performance New Zealand.



Invited Speakers

Stephen Hotter

Mr Hotter is the Head of Strength and Conditioning at High Performance Sport New Zealand, a position he has held for the nearly 4 of his 12 years with the organisation. He started his career working with New Zealand Rugby Union teams. Since he joined HPSNZ he has also been an S&C coach for National Cricket and Netball teams and assisted in preparing New Zealand's Preparation and Recovery Area for the Rio 2016 games. Currently Mr Hotter's primary role is as the Head Strength and Conditioning coach for the Silver Ferns. Mr Hotter is also a founding member of SESNZ's New Zealand Strength and Conditioning Accreditation (NZSCA) programme.



Simon Jones

Mr Jones joined the Pulse Energy Highlanders as their Strength and Conditioning coach at the end of 2019. This follows from his success as the Head S&C coach for the Brave Blossoms, leading up to the 2019 Rugby World Cup. As well as coaching rugby he has worked with national level Netball teams while he was a Senior S&C Specialist for High Performance Sport New Zealand.



Keynote Presentations

SOBI: Sport Originated Brain Injury

Patria Hume¹

¹*Auckland University of Technology*

This presentation will cover current issues for consideration by sport and exercise science professionals including understanding the mechanisms of injury, means of assessment, and recovery management options.

Wearing Sensors in Biomechanics

Thor Besier¹

¹*University of Auckland*

Exercise Fit for the Environment

Jim Cotter¹

¹*University of Otago*

For those who've it out of bed for this session following the conference dinner, we'll start the day with something light: Our population is increasingly unfit to withstand both the environment it is building itself and the one it is destroying by way of that process. And, high-performance sport has more skin in this game than it might appear; more to lose, to gain and to contribute. Brilliant - so why did we get out of bed? One reason is that this contextualises the science of exercise and sport as having more relevance and potential now than it ever has. In this presentation/session we will address exercise and the physical environment (terrain and climate) in three contexts, across the range of human capacity, from clinical to elite. First, we address the unique merit of being fit for providing people with the ability to engage in, enjoy and withstand the physical environment. Second is the merit of engaging in exercise that's fit for the environment. Third is the merit of the environment for providing people with fitness. Your participation is preferred (see Figure 1).



Figure 1: Is this (a) a maze, (b) the true relation between two variables when a ground-breaking publication has reported evidence for a strong relation, or, (c) a QR code for a quiz, which is also accessible at this address:

<http://www.maths.otago.ac.nz/oclick>

Recruiting the Cognitive Unconscious for Better Performance in Sport

Rich Masters¹

¹*University of Waikato*

A useful departure point for examining learning and performance in sport is the distinction between conscious and non-conscious processes. This presentation will seek to show the power of non-conscious processes in sport and will present evidence that has accumulated over many years, which suggests that there are significant advantages of acquiring skills unconsciously (implicitly) rather than consciously (explicitly). The presentation will describe methods used to cause implicit motor learning and will review potential mechanisms that may underlie performance advantages associated with implicit motor learning.

The Art and Science of Coaching

Scott Robertson¹ and Simon Thomas¹

¹*BNZ Crusaders*

Scott and Simon will be hosting a Q&A discussion on their coaching methods. Reviewing how they use interpersonal skills to maximise the results of science-based coaching.

Invited Presentations

Silver Ferns Gold Medal Journey to the Netball World Cup 2019

¹Stephen Hotter

¹*High Performance New Zealand*

A presentation on the Silver Ferns Gold Medal Journey to the Netball World Cup 2019 with the major focus being on the preparation in the 12 months leading into the event i.e. what we wanted to achieve from both a tan and Strength and Conditioning perspective, and how we went about trying to achieve that. There will be some focus also on the event itself and how we operated during the 10 days of the tournament.

Japan Rugby preparation for Rugby World Cup

¹Simon Jones

¹*High Performance New Zealand*

A retrospective look at how a coaches' challenge led to a simple use of GPS data to create change and prepare the team to execute their unique game plan, surprising many at the 2019 RWC. How the simple things done well, and a high level of alignment between coaching and sport science led to high player buy-in and results

SOBI: Concussion Panel

CONCUSSION PANEL: Should contact sports be limited for children under 12 years to reduce sport originated brain injury?

¹⁻⁴Professor Patria Hume, ⁴Associate Professor Mel Bussey, ^{1,3}Mr Joshua McGeown, ⁵ Professor Nick Draper, ^{6,1}Dr Ken Quarrie

¹*Sports Performance Research Institute New Zealand (SPRINZ), Auckland University of Technology (AUT), Auckland, New Zealand*

²*National Institute of Stoke and Applied Neurosciences (NISAN), AUT, Auckland, New Zealand*

³*Traumatic Brain Injury Network, AUT, Auckland, New Zealand*

⁴*School of Physical Education, Sport and Exercise Sciences, University of Otago*

⁵*School of Health Sciences, University of Canterbury*

⁶*New Zealand Rugby*

The aim of this panel is to provide for SESNZ members a multidisciplinary discussion on evidence for and against whether contact sports should be limited for children under 12 years to reduce sport originated brain injury.

There has been a previous call for a ban in tackling in rugby in the UK, and discussion on risk assessment in sport. There is emerging evidence that 12 years of age may be a good threshold for contact sport engagement for a variety of sports. However, questions have been raised over whether

banning tackle rugby for children could actually increase the risk of sport originated brain injury when they start tackle rugby at a later age. As children mature, they get taller, heavier, and faster which enables them to impart more energy during impacts that potentially increase the risk of injury. The risks of concussion for rugby players aged 7-12 is low based on ACC statistics; however, it increases as players get older and therefore bigger and faster. There are issues with chronological 12 years being the contact sport threshold from a growth and biomechanics view point. Each panel speaker will outline key points from their research and indicate the relevance to children:

- Associate Professor Mel Bussey, Te Kura Para – Whakawai – School of Physical Education, Sport & Exercise Sciences, Universtiy of Otago – *Snow sports and causes of head injuries in children.*
- Mr Joshua McGeown, Auckland University of Technology – *Recovery implications for children from SOBI.*
- Professor Nick Draper, School of Health Sciences, University of Canterbury – *Maximising mitigation of head injuries for children: headgear and beyond.*
- Dr Ken Quarrie, NZ Rugby – *Approaches by NZR and the issues of contact sport for children.*

The panel discussion will include Q&A from the delegates.

Workshops

Olympic lifting Masterclass

¹John Wilson

¹*High Performance Sports New Zealand*

To stimulate the attendee to think there are other metrics to weightlifting that strictly load. This ‘masterclass’ is a mix between some alternative metrics for assessing Olympic lifting and a practical demonstrating my progressions for teaching the lifts and how certain cues can increase the desired outcome.

The science and practice of eccentric training.

¹Angus Ross

¹*High Performance Sports New Zealand*

Talk will cover learnings from track cycling where world records continue to be broken by substantial margins and how the changes made in cycling have implications for other modalities. The intersection of biomechanics and physiology is relatively easily studied in cycling and can perhaps give us insights as to how sprint running could also be optimized. No definitive answers but some interesting anecdotal results from track and field world record holders that both align with the findings from cycling and suggest value in some unconventional training strategies.

Oral Presentations

Sport Science

1. Running demands in women's rugby

¹Busbridge, A.R.; ²Hamlin M.J.; ^{1,3}Jowsey J.A.; ³Vanner, M.H.; ¹Olsen, P.D.

¹Department of Applied Sciences and Social Practices, Ara Institute of Canterbury, Christchurch, New Zealand

²Department of Tourism, Sport and Society, Lincoln University, Christchurch, New Zealand

³Canterbury Rugby Union, Christchurch, New Zealand

Introduction: Rugby union is a dynamic field based collision sport requiring technical skill and physical conditioning. There has been rapid growth in women's rugby worldwide, yet there is limited research determining the physical demands of the sport. Measuring running demands with GPS could aid in the design of training programmes, which are specific to players needs in competition. Consequently, we quantified the running demands of female rugby players in national provincial matches. **Method:** Twenty players from a Farah Palmer Cup team participated in the study. Players wore 10 Hz GPS units during seven games to measure total distance covered, all running distance ($\geq 6.4 \text{ km}\cdot\text{h}^{-1}$), high intensity (HI) running ($\geq 16.1 \text{ km}\cdot\text{h}^{-1}$) and maximum speed ($\text{km}\cdot\text{h}^{-1}$). Data was divided into six positional groups (front row, locks, loose forwards, inside backs, midfield backs and outside backs). **Results:** All players travelled a similar total distance during matches ($5887 \pm 326 \text{ m}$). Outside backs spent ~60% of matches walking and did less running ($2456 \pm 114 \text{ m}$) than other positions ($p \leq 0.05$). In contrast, the half back recorded significantly higher running distances ($4292 \pm 171 \text{ m}$), greater HI running distances ($1003 \pm 58 \text{ m}$), and more distance overall ($6812 \pm 277 \text{ m}$) than other positions ($p \leq 0.05$). Maximum velocity for backs was higher than forwards ($26.3 \pm 0.3 \text{ km}\cdot\text{h}^{-1}$ vs $22.4 \pm 1.1 \text{ km}\cdot\text{h}^{-1}$). **Discussion:** Physical demands experienced by women's rugby union players varies depending on playing position. To adequately prepare athletes for competition, coaches and trainers should consider individual match demands in training. **Take home message:** The half back position is very demanding in terms of low and high-speed running whilst outside backs covered less distances at higher speeds and running in general. Therefore, position specific conditioning practices and coaching tactics such as selection should reflect these findings.

2. Examining footwear manufacturer websites – Is the industry ahead of science?

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Introduction: Footwear characteristics in running-related research are inconsistently reported. This has led to difficulties comparing results across studies and provides poor evidence regarding the impacts of footwear on injury, performance and biomechanics. The objectives of this study were: (1) to document the footwear characteristics reported on footwear manufacturer's websites, (2) to evaluate the quality of manufacturer websites and (3) develop criteria for reporting footwear characteristics. **Method:** Four location-disabled internet search engines: Bing, Google, Yahoo, DuckDuckGo were used to identify footwear manufacturer websites. Search terms included 'running footwear' and 'running shoes'. Data was extracted from the included websites on up to four different footwear models per manufacturer, and included characteristics such as: nomenclature used, objective footwear measurements and advice provided to runners. **Results:** Eighty footwear models were evaluated from 24 websites that were deemed as poor-quality as health-related web resources. There is a consistent use of nomenclature when describing footwear type (i.e. minimalist, motion control, neutral), across all manufacturers, however, there is a wide variety of measurements and characteristics reported by the manufacturers. Additionally, a content analysis of the advice provided to runners is inconsistent with current research and may be used purely for marketing purposes. Preliminary development of a footwear reporting protocol includes 28 items categorised into 12 components. **Discussion:** Despite the availability of consensus footwear definitions and valid assessment tools, reporting of footwear characteristics on manufacturer websites is inconsistent. Manufacturers could improve the information provided by using a standard reporting protocol. This protocol could also be used in the academic literature and as a result, help improve the reporting quality of the studies on the impacts of footwear on injury, performance, and biomechanics. **Take home message:** Currently, the footwear industry appears to report footwear nomenclature more consistently than the academic literature of the past four decades. Future Delphi studies are needed to develop reporting protocols that span the scientific and footwear industry sectors.

3. The influence of COVID-19 lockdown restrictions on perceived nutrition & training habits in rugby union players

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Introduction: The global spread of COVID-19 has led to governments and local authorities implementing nationwide lockdowns to minimize the spread of the virus. In New Zealand, all non-essential businesses and services closed or restricted activities. **Methods:** Two surveys were distributed among Rugby Union players to establish (1) the influence of COVID-19 lockdown restrictions on Rugby Union players' perceived nutrition and training habits and (2) how perceived nutrition and training habits in Rugby Union players' changed following relaxation of lockdown restrictions. **Results:** Of the 258 respondents who completed Survey 1 (84.1% male, 26.4% professional/semi-professional), 58% indicated living with family during lockdown. Total food intake was reported to be higher in 36% of respondents. Fruit and vegetable intake was lower (17%) and packaged/convenience food intake higher (26%) in a minority of respondents. In total, 106 respondents completed Survey 2 (84.9% male, 34.0% professional/semi-professional). Of these, 72% prepared and 67% purchased their own food. Compared to during lockdown, motivation to train and exercise was greater in 58% of respondents following lockdown. Dieticians and nutritionists within clubs provided most nutrition information/knowledge to athletes however other unreliable sources were identified, such as social media and family members. **Discussion:** Due to the unprecedented and unique nature of the COVID-19 pandemic, literature concerning lockdowns on athletes' nutrition and training habits is scarce. With matches and group training sessions cancelled and gyms, eating establishments and workplaces closed, Rugby Union athletes' experienced significant disruption and changes to their daily lives. **Take home message:** The on-going pandemic has presented significant challenges for athletes concerning perceived nutrition and training habits. Coaches and performance staff should ensure athletes' receive appropriate and reliable nutritional and training support whilst being aware of the unique demands the individuals' may face.

4. Physical activity and mental health during COVID-19 lockdown: an international comparison

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Introduction: At the onset of the COVID-19 pandemic, national governments implemented strict containment strategies to limit the spread of the virus. This study assessed physical activity, mental health and wellbeing during COVID-19 restrictions in adults across the UK, Ireland, New Zealand and Australia. **Method:** An online survey was distributed in each country using convenience sampling, within 2-6 weeks of government mandated COVID-19 restrictions. During the COVID-19 restriction period, participants completed the Stages of Change scale in relation to exercise behaviour change, the International Physical Activity Questionnaire (short-form), World Health Organisation-5 Well-being Index and the Depression Anxiety and Stress Scale-9. Participants also completed the Stages of Change scale for exercise behaviour change with respect to pre-COVID-19 restrictions. **Results:** In a sample of 8,425 people, individuals who reported a negative change in exercise behaviour between pre- and during COVID-19 restrictions demonstrated poorer mental health and wellbeing ($p < 0.001$). Whilst women reported more positive changes in exercise behaviour, young people (aged 18-29 years) reported more negative changes (both $p < 0.001$). Although there were no differences in physical-activity participation between countries, New Zealand reported significantly higher mental health and wellbeing ($p < 0.001$) while Ireland reported significantly lower ($p < 0.001$). The UK and Australia had significantly greater negative change in exercise behaviour than NZ or IRE ($p < .0001$). **Discussion:** These findings have important implications for policy and guideline recommendations to encourage people to be physically active, as well as targeting known groups (i.e., men, young adults) who are more likely to become less physically active and experience poorer mental health and wellbeing outcomes during periods of physical distancing. **Take home message:** During the height of the COVID-19 restrictions, people who reported a negative change in exercise behaviour between pre- and during-COVID-19 restrictions demonstrated poorer mental health and wellbeing.

5. Longer sleep duration enhances training adaptations in a military population

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Introduction: Sleep is vital in influencing effective cognitive and physical performance in the military. This study aimed to assess the relationship between sleep and changes in physical performance over 6-weeks of military training. **Methods:** 22 officer trainees (age: 24 ± 10 y) from the New Zealand Defence Force wore wrist actigraphs to monitor sleep, completed subjective wellbeing

questionnaires weekly, and were tested for; 2.4 km run time-trial, maximum press-up and curl-ups before and after 6-weeks of military training. Average sleep duration was calculated over 36-nights (370 ± 28.2 min), and sleep duration was used to stratify the trainees into two quantile groups (Unders: $5:51 \pm 28.5$ h:min, $n = 11$) and (Overs: $6:27 \pm 9.0$ h:min, $n = 11$). **Results:** 2.4 km run time, press-ups, and curl-ups all improved (all $p \leq 0.01$). There was no significant group \times time interaction for 2.4 km run, press-ups, or curl-ups ($p > 0.05$); however, small clear effects were observed in favour of Overs for 2.4 km run (59.8 vs 44.9 s; $d = 0.26$) and press-ups (4.7 vs 3.2 reps; $d = 0.45$). Subjective wellbeing scores showed significant differences ($p < 0.05$) with large effect sizes in favour of the Overs group for Fatigue in Week 1 ($d = 0.90$) and Week 3 ($d = 0.87$), and Soreness in Week 3 ($d = 1.09$) and Week 4 ($d = 0.95$). **Discussion:** Overall sleep duration did not meet recommendations; although training did improve aspects of physical performance. In this cohort, longer sleep duration was associated with greater physical adaptation and decreased fatigue during an intensive training period, likely due to an increased capacity to recover. **Take home message:** Sleeping more than 6:15 h:min was associated with small benefits to aspects of physical performance and moderate to large benefits on subjective measures when compared to sleeping less than 6:15 min.

6. Energetic and cognitive demands of different water treading patterns

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Introduction: Water treading is one of the most useful ways to stay afloat: Being able to tread water effectively improves the chances of survival in an immersion accident. People tread water in a variety of ways, ranging from “doggy paddle” to an elaborate “eggbeater” technique, but little is known regarding the economy and cognitive requirements of these different patterns. We therefore aimed to determine whether the eggbeater technique is (as has been suggested) the most energetically and cognitively economic treading pattern. **Methods:** We tested adult water treading experts (i.e., water polo players, $N = 19$), intermediate swimmers ($N = 16$) and inexperienced swimmers (i.e., basic swimming skills present, $N = 17$). Participants were asked to tread water for 3 minutes in each of 5 patterns: their preferred pattern and four instructed patterns, which were demonstrated on video. Subjective (RPE, NASA TLX) and objective measures of cognitive and energetic load (probe reaction time, oxygen consumption, heart rate) were assessed. **Results:** Preliminary analyses in the expert population showed that the eggbeater, as well as an upright breaststroke technique,

were associated with significantly lower metabolic load (oxygen consumption, heart rate), subjective task load, and perceived exertion compared to other techniques. Probe reaction time did not differ significantly between techniques. **Discussion:** These findings indicate that amongst experts, both the eggbeater and upright breaststroke technique may be effective ways to tread water. A next step will involve analysing the full dataset to investigate what factors determine the optimal technique for an individual of any skill level. These findings will help practitioners select the optimal water treading technique to teach to learners. **Take home message:** In experts, at least, it seems that the “eggbeater” technique as well as upright breaststroke may be preferred options to “stay afloat, and stay alive”.

7. Exploring head control during impact perturbations in rugby players with history of concussion

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Introduction: There is a growing body of evidence identifying the connection between concussion, altered neuromuscular control and recurrent injury risk in athletes. Poor neuromuscular control of the head may increase an athlete’s risk of subsequent concussions upon return to sport. In this study we examine the effect of concussion history on neuromuscular responses in the cervical muscles when a player is exposed to predictable and unpredictable impact perturbations. **Methods:** An observational cross-sectional study design with 34 players, 23 <26 month since concussion 11 >36 months since concussion. 10 perturbations were applied with a relatively weighted device. EMG was recorded from the splenius capitis, upper trapezius and sternocleidomastoid and head accelerations were recorded with CSx triaxial accelerometer. **Results:** The mixed model analysis showed that players <26_mths since concussion had higher rotational acceleration of the head during unpredictable impacts (CI 0.885-399.77, $p < 0.049$). Within the <26 month group, those with 3+ concussions experienced delays in SCM and SPL in unpredictable conditions (CI 1.1–45.1 ms, $p = 0.025$; 4.1-54.3 ms, $p = 0.023$) and early activation of these muscles in predictable (CI 6.9–103.4 ms, $p = 0.040$; 14.9-121.0 ms, $p = 0.012$) conditions compared to those with 1-2 concussions. **Take home message:** History of concussion has an effect on head control response during impact perturbations. The findings imply that athletes with 3+ concussions are more reliant upon vision when preparing for an impact and may experience significant neuromuscular deficits in cervical spinal muscles for up to 2 years post-concussion.

8. Effect of altitude training on basketball performance

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Introduction: The aim of this study was to investigate whether adding hypoxia to 4 weeks of repeated sprint and high-intensity training improved explosive muscular power, aerobic performance and repeated sprint ability in 3x3 basketball players. **Methods:** Eleven well trained female basketball players, were randomly assigned to a hypoxia (H) (n = 5; age: 20.0 ± 1.6; height: 169.4 ± 4.6; body mass: 76.9 ± 6.5; haemoglobin: 135.8 ± 4.1) or control (C) group (n = 6; age: 20.8 ± 2.2; height: 174.7 ± 5.2; body mass: 68.0 ± 4.3; haemoglobin: 128.2 ± 11.3). The training programme applied during the study was the same for both groups, but with different environmental conditions during the selected interval training sessions. All subjects performed two high intensity interval training sessions per week in addition to two team trainings for a total of 4 weeks. During the interval training sessions the Hypoxic group trained in a normobaric hypoxic chamber at a simulated altitude of 3000 m (FI02 = 15.2), while the Control group performed similar training under normoxia conditions also inside the chamber. Players were blinded to the oxygen concentration in the chamber. Training sessions consisted of 6 sets of 30s reps with 30s rest between reps and 2 min rest between sets for a total of 60 min per training session. Approximately 1 week before and 1 week after training, explosive muscular power (counter-movement jump peak power, peak velocity and distance) aerobic performance, (Yo-Yo Intermittent Recovery Test L1) and repeated sprint ability (number of times players covered a 17 m distance in 1 min) were measured. A Student's Paired t-test along with magnitude-based decisions was used to analyse differences between group's pre and post training. **Results:** At baseline the two groups were similar in all characteristics apart from repeated sprint ability where the control group was able to cover significantly more ground during the test (8.5 ± 5.6 m, mean ± 95% CI) and height where the control group was significantly taller than hypoxic group (5.3 ± 3.7 cm, p = 0.02). Compared to the control group, the hypoxic group showed a likely increase in distance covered during the repeated sprint test (9.1 ± 9.0 m, p = 0.05), as a result of training, however, all other variables showed unclear differences between the groups. **Discussion / Take home message:** Adding hypoxia to high intensity training clearly improves repeated sprint ability in 3x3 female basketball players, however, the effect of hypoxia on muscular power and aerobic fitness is unclear.

9. Developing a successful S&C environment

¹Simon Thomas

¹BNZ Crusaders

Encouraging ownership in athletes and staff, integrating technology while putting people first, collaborating across departments with cohesion.

10. Clarifying the role of the strength and conditioning coach in athlete rehabilitation

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Introduction: Strength and conditioning (S&C) coaches are traditionally thought of as performance professionals, but the principles of S&C may be utilised in athlete rehabilitation. The role of S&C coaches in athlete rehabilitation has not been documented. Some S&C coaches collaborate with physiotherapists in athlete rehabilitation. Therefore, this study aimed to clarify the role of S&C coaches in athlete rehabilitation from the perspectives of physiotherapists and S&C coaches. **Method:** Semi-structured interviews were conducted with one S&C coach with a background as a physiotherapist, four physiotherapists, and four S&C coaches across New Zealand. **Results:** A thematic analysis of the interview data identified thirteen themes that were analysed in four categories. These themes in their respective categories were: Current role (teamwork with the rehabilitation team, level of involvement, and physical roles), proposed role (teamwork with the rehabilitation team, level of involvement, and physical roles), variables (rehabilitation team structure, governance, relationships in the rehabilitation team, and the athlete), and significance (positive and negative). **Discussion:** The current perceived role of S&C coaches relates well to the literature that is available. Most S&C coaches seem to have a small role in the end stages of athlete rehabilitation and take over from physiotherapists to provide performance training. Participants thought that S&C coaches should have a much greater role than this. **Take home message:** Participants thought that S&C coaches can provide performance context to the athlete rehabilitation process, but poor communication and collaboration with health professionals reduces their role. Participants thought S&C coaches should be minimally involved following a health professional's diagnosis. Their involvement should then increase as athlete function improves and the physiotherapist's role decreases. Their greatest involvement would be in performance training. Participants agreed that the S&C coach's role should be flexible and account for the context of rehabilitation and their own personal skillset.

11. The impact of small-sided conditioning games on rugby union youth

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Introduction: Evidence from the football codes suggests small-sided games (SSGs) can be used for physical, skill, and tactical development. This research aimed at clarifying how SSG design variables differentially affect rugby union (RU) youth. **Method:** An e-survey on SSG practice and a systematic review were finalised. An intervention pilot study on talented rugby union youth (n=96) preceded an on-going follow-up investigation into U18 male school rugby union SSG-play, using the Borg scale and microsensor devices. **Results:** The evidence demonstrated that 84% of regular practice incorporates SSGs, although the design and intended outcomes vary across target groups. This prevalence is evident despite current inchoate literature showing only 7 studies with a high risk of bias. Overall perceived exertion (RPE) in talented RU youth was 13.19 ± 2.57 , ranging widely [7.67–19.33]. Differences were obtained for sex (M: 13.53 ± 2.66 vs. F: 12.84 ± 2.43 ; $p=0.074$), pitch size (13.54 ± 2.54 (35x50 m) vs. 12.74 ± 2.55 (25x35m); $p=0.040$), and player number (13.90 ± 2.71 (3 v 3) vs. 12.44 ± 2.20 (5 v 5); $p < 0.01$). These results will be complemented with data on RPE, physiological, and kinematic outcomes for different SSG formats in U18 male rugby union players. **Discussion:** SSGs^{RU} are prevalent and their application is differentially context-bound. The literature is in its early stages and needs methodological rigidity to form solid guidelines. A structural approach to SSG design affirms the importance of context-specific differentiation; increasing playing area and decreasing player numbers can elevate intensity. Males appear to execute or experience standardised games at a higher intensity than females. **Take home message:** Researchers should aim for high-quality structural investigation of causal relationships between basic design variables and relevant outcome measures. Practitioners should interpret the evidence within its context and apply SSGs with specific intent whilst monitoring high intensity.

12. Eccentric force-load-velocity characteristics and relationships with performance measures in trained rugby union athletes

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Introduction: The force-velocity relationship is traditionally thought to resemble a hyperbolic shape, known as the “force-velocity curve”. The interaction between these variables contribute to the foundation of knowledge used by practitioners to design training programs. However, there is little evidence regarding the force-velocity-load relationship during eccentric muscle action, especially in applied settings. The purpose of this study was to investigate the force-velocity-load relationship in an eccentric back squat test and then analyse the strength of association between these characteristics and measures of physical

ability. **Method:** 37 professional male rugby union athletes were recruited to participate. A general linear mixed model was used to analyse relative eccentric peak force (REPF) and eccentric peak velocity (EPV) with playing position used as a random effect and system load used as fixed effect covariates. A Pearson’s product-moment correlation test was then conducted between the levels of the eccentric squat test (20-120kg) and each performance measure (10m, 20m, flying 10m, counter-movement jump, and maximal squat strength). **Results:** For forwards, moderate to large significant correlations were found between REPF at heavier weights and jumping ability. There were large to very large correlations between EPV at each load for sprinting ability and squat strength. Backs exhibited large significant correlations between sprinting and REPF at 20kg and jumping at 100 and 120kg. EPV at 100kg was significantly correlated to jumping. **Discussion:** Playing position in rugby union may contribute to the individualised movement strategies during the eccentric phase of explosive actions. Stronger associations were observed between eccentric characteristics and athletic ability in forwards than backs. **Take home message:** Rapid, multi-joint eccentric contractions performed across a spectrum of loads provided insight into athletic capability. Further research may endeavour to understand the extent to which these qualities are trainable as well as the causal nature of eccentric characteristics and athletic performance.

13. Football small-sided games and sprint demands: Can we push the boundaries?

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Introduction: Sprinting during soccer training is key for reducing injury and enhancing performance. While many coaches prefer to meet physical training objectives using soccer-specific exercises such as small-sided games, assessment of SSG sprint demands is limited, and lacking the real-world deliberate manipulation of prescriptive variables. **Method:** This study reports the sprint demands of several small-sided games (SSG) and investigates the effect of rule modifications designed to increase sprinting opportunities. Twenty under-17 players performed nine SSG across three levels of player number (5v5, 7v7, 9v9), within 150 m² (SG) and 320 m² (LG) relative pitch areas, with an additional variation (CG) utilising counterattack-focused rule modifications. Individualised GPS variables were recorded using 10 Hz GPS devices. **Results:** LG and CG resulted in peak speeds of 85-90% of MSS (maximal sprint speed), while only a very limited number of players exceeded 95% of MSS in any game. Analysis using linear mixed-effects models indicated differences in sprint demands across SSG variations. Pairwise testing of estimated marginal means revealed greater relative peak sprint speeds, (LG: ES=1.82, $p < 0.0001$; CG: ES=1.85, $p < 0.0001$), number of efforts above 80% MSS (LG: ES=1.28, $p < 0.0001$; CG: ES=1.20, $p < 0.0001$) and distance covered above 80% MSS (LG: ES=1.11, $p < 0.0001$; CG:

ES=1.34, $p<0.0001$) in LG and CG compared to SG. **Discussion:** The LG and CG (both 320 m² relative pitch area) games resulted in comparable sprint demands, suggesting that increased pitch area is possibly the main variable affecting SSG sprint demands. These games may also be reaching the upper limit of sprint speed players can

achieve during SSG. **Take home message:** The equivalence of LG and CG underline that verifying training exercise demands against their intended outcome is essential. Match-specific relative pitch area SSG may be useful for reaching approximately 90% of MSS but unlikely to reach greater speeds.

Performance Analysis

14. An evaluation of data sources in netball performance analysis

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Introduction: The importance of feedback has been acknowledged in literature as it enhances learning and has positive psychological impacts upon players. The balance between positive and negative feedback is a significant consideration, as is the relevance or ecological validity of that information. Ecological validity is a concept that has been widely debated and has been misunderstood by researchers when claiming their research is representative of the “real world”. The provision of data to coaches in real-time should consider if this information is ecological valid to the coach. The benefit of recording events and presenting summarised feedback information to coaches has been previously demonstrated as extremely relevant for accurate

decision making. However, limited research has attempted to align this feedback information with coaches’ reactive behaviours. It has been argued that many data-producing and data-presenting technologies do not actually align with coaches planning and their approach to a sports match. Prior research provided insights into coach communication during netball matches. **Methods:** The themes they identified will be used as criteria for the selection of data for coaches during a match, creating a more ecologically valid approach to data-feedback during sports matches. This study will determine and evaluate the information systems and types of data that are available to coaches, in real-time, during netball sport matches. These data-types will then be evaluated for alignment with the themes identified in previous content analysis. **Discussion/Take home message:** Recommendations will then be made for the use of data-types in assisting coach’s decision-making and player skill acquisition. This study will also provide a useful guide for performance analysts when designing information technologies for use during matches.

Biomechanics

15. Laboratory validation of instrumented mouthguard for head impact measurement in sport

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Introduction: Concussion is an inherent risk of participating in contact, combat and collision sports, within which, head impacts are numerous. To the best of the current understanding, kinematic parameters such as the peak linear and peak rotational accelerations are the main predictors of concussive head impacts. The ability to accurately measure and categorise such impact parameters in real-time is gaining importance. The purpose of this study was to assess the accuracy of the latest HitIQ Nexus A9 instrumented mouthguard (HitIQ Pty. Ltd.) against reference sensors in an Anthropometric Test Dummy (ATD) headform. **Method:** The headform was impacted at various intensities for a standard set of NOCSAE-defined drop test impact locations, comparing the peak linear and rotational accelerations as well as the shapes of the acceleration time

series traces for each impact. The peak linear and rotational accelerations measured by the instrumented mouthguard and the reference sensors had intraclass and concordance correlation coefficients of 0.997. The root mean square error between the measurement devices was 1g with a standard deviation of 0.6g for linear acceleration and 47.4rad/s² with a standard deviation of 35rad/s² for rotational acceleration. **Results:** Bland-Altman analysis found a systematic bias of 1% for peak rotational acceleration, with no significant systematic bias for peak linear acceleration. **Discussion/Take home message:** The results indicated that the tested instrumented mouthguard is a valid tool for measuring head impact kinematics in the laboratory setting, and could serve as a reliable instrument for measuring and quantifying real-time head impacts, whilst expanding the current understanding of concussive head injuries.

16. Load carriage

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Introduction: Soldiers in the NZ Army are required to be physically fit in order to be able to conduct any task presented to them whether in a training environment or on operation. With excessive loads regularly required to be carried by soldiers coupled with tasks that are equally as physically demanding, Army Physical Training Instructors (PTI's) face a multifaceted training situation. With the added pressure of limited training frequency, time restraints, limited facilities and equipment Army PTI's must be resourceful, adaptable and intuitive in their training methods. So how do NZ Army PTI's approach training their soldiers to meet the physical and mental demands of load carriage?

17. Neck posterior chain considerations for pilots

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Introduction: There is a high prevalence of neck pain in the pilots and crew members of Air Force populations worldwide. Pilots are 1.5-3.5 times more likely to experience back or neck pain during their flying career. The health of all New Zealand Defence Force (NZDF) personnel is of primary concern so they can perform their role optimally in service to New Zealand. This presentation will cover how we have addressed this problem within the Royal New Zealand Airforce (RNZAF) from a prevention view point, issues we face and what we are striving to do moving forward. It will also cover practically what the Physical Training Instructors (PTIs) at Base Ohakea are going to implement in 2021 to help both 14 and 3 squadron reduce and prevent neck issues.

18. The influence of ankle dorsiflexion range of motion on unanticipated cutting kinematics

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Introduction: Limited dorsiflexion range of motion (ROM) has been related to Anterior Cruciate Ligament (ACL) injury risk during landings. However, the influence of dorsiflexion ROM on cutting kinematics is unknown despite high incidence of knee injuries during such tasks. **Method:** Dorsiflexion ROM was measured for each leg using the Weight-Bearing Lunge Test (WBLT) in 42 participants. Participants subsequently performed unanticipated side-step cutting. Ankle, knee, hip, and trunk angles and pelvis linear accelerations in all planes were collected at initial contact (IC) and between IC and maximum knee flexion using a three-dimensional motion analysis system and inertial measurement units. Pre-contact foot-ground angles were also extracted. Multiple linear regressions with sex as a confounder were used to explore relationships between cutting kinematics and WBLT dorsiflexion ROM for both dominant and non-dominant extremities. When non-significant, the sex confounder was removed from analyses. **Results:** Mean and standard deviation dorsiflexion ROM

values from the WBLT were $51.33^\circ \pm 6.48^\circ$ and $50.21^\circ \pm 7.00^\circ$ on dominant and non-dominant legs, respectively. For dominant leg cutting, transverse plane knee ROM increased 0.20° ($p = 0.037$), sagittal plane trunk ROM increased 0.16° ($p = 0.044$), and trunk flexion at IC decreased 0.39° ($p = 0.009$) for each degree of WBLT dorsiflexion ROM recorded. Males had 5.89° greater trunk flexion at IC compared to females. For non-dominant leg cutting, peak lateral trunk flexion towards the stance leg, as well as sagittal and coronal plane hip ROM increased 0.36° ($p = 0.039$), 0.24° ($p = 0.017$), and 0.21° ($p = 0.005$) for each degree of WBLT dorsiflexion ROM, respectively. **Discussion:** It seems that both limited and excessive dorsiflexion ROM may influence cutting kinematics and contribute to ACL injury risk. **Take home message:** The use of clinical measures of dorsiflexion ROM for screening purposes may be useful in cutting sports.

19. Loading and structural performance of tandem bicycle frames

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Introduction: This work concerns the loading applied by the athletes to a tandem bicycle during racing efforts and the implications for design of the frame. Eight cycling medals out of the 50 awarded at the Paralympic Games are in category B (blind or partially sighted) and contested on tandem bicycles. Tandem frame design is a challenge: low mass is desired for high performance but the forces, and resultant moments, applied in race starts may be more than double those applied to a solo bicycle and the length amplifies undesired deflections. Strict rules govern frame geometry but, in contrast to the situation for solo bicycle design, no single overall design layout has yet been universally adopted for tandem frames. **Method:** We have developed a method to calculate the forces applied to a tandem frame as a function of the athlete effort and the driveline layout. Computational finite element analysis is used to simulate the application of these forces to a range of tandem frame designs. **Results & Discussion:** Strength, stiffness and mass are reported for alternative tandem frame designs. The implications for design and the merits of different frame layouts are discussed. **Take home message:** The combination of forces from two athletes and the extra length of a tandem bicycle present a particular engineering design challenge. We present a method for assessing the structural performance of frame designs.

20. Accumulated PlayerLoad in fast bowlers across maximal and submaximal intensities; comparison of upper back and non-bowling wrist IMUs.

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Introduction: PlayerLoad has been introduced as a potential improvement to traditional internal and external

workload estimates in fast bowlers. However, it is not yet known how to best define PlayerLoad from IMU data, nor what effect, if any, Inertial Measurement Unit (IMU) placement may have on the PlayerLoad outcome measures. This study compared accumulated to maximum PlayerLoad in two locations (upper back and non-bowling wrist) across maximal and submaximal intensities to determine whether a workload variable could be extracted that correlates with release speed. **Method:** Sub-elite and elite fast bowlers (n=8) bowled one over at 60%, 80% and 100% intensity in each session. Ball release speed was measured for each ball; IMUs were placed on the upper back and non-bowling wrist. Pearson's correlations were calculated between potential workload variables and release speed. **Results:** Accumulated PlayerLoad had stronger correlations with release speed compared to maximum PlayerLoad, with either the non-bowling wrist or upper back being an appropriate location to calculate PlayerLoad from. Correlations are generally weaker at submaximal intensities but is an important consideration when estimating workload in fast bowlers. **Discussion:** Accumulated PlayerLoad appears to provide a better estimate of workload in fast bowlers likely because it accommodates the entire movement pattern over the course of each delivery as opposed to the previously proposed method of maximal PlayerLoad. The use of a non-bowling wrist IMU provides a comparable workload estimation and could help to differentiate between bowling and throwing events. **Take home message:** Examining the accumulated PlayerLoad across each delivery provides a better estimate of workload compared to the maximum PlayerLoad, so should be calculated when possible.

21. The relationship between release speed, heart rate and RPE across maximal and submaximal intensities in fast bowlers

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Introduction: Bowling workload is an accepted risk factor for all injury types among fast bowlers and can be defined in terms of the internal and external load on the body. External workload is commonly measured by counting the number of balls bowled over a certain time period. Internal workload refers to the amount of stress that is placed on the internal structures of the body. This study examined the relationships between potential internal workload estimates (heart rate and rate of perceived exertion (RPE)) and release speed in order to determine which variable provides the best estimate of internal workload across maximal and submaximal intensities. **Method:** Sub-elite and elite fast bowlers (n=8) bowled three overs, one each of 60%, 80% and 100% intensity. Release-speed was measured for each ball while RPE (Borg; 6-20) and heart rate recorded for each over. Relationships between variables were examined using Pearson's correlation coefficients and equivalence testing. **Results:** Bowlers were able to scale their effort with prescribed intensities. There were significant correlations between release speed and peak heart rate ($R = 0.80$ [0.67, 0.88]), average heart rate ($R = 0.68$ [0.48, 0.81]) and RPE ($R = 0.77$ [0.63, 0.87]) when examine relative to participant maximum values. **Discussion:** Either heart rate or RPE could be used as an internal workload estimate across maximal and submaximal intensities. Both variables require considerations in order to maximise their effectiveness, which include: When to obtain ratings of perceived exertion, the specific heart rate variable to use and also how to handle the different heart rate responses that are likely to be seen when comparing training and matches. **Take home message:** Internal workload can be estimated easily in fast bowlers. Examining both internal and external measures should allow the best estimation of total bowling workload.

Exercise Physiology

22. On-field movements, heart rate responses and perceived exertion of lead referees in Rugby World Cup matches, 2019

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Introduction: Quantify the on-field movements, heart rate and perceived exertion (RPE) of lead referees during Rugby World Cup matches. **Design:** Descriptive, observational **Methods:** On-field movements (distance, average speed, high-speed running [>5 m·s⁻¹]), heart rate and RPE of 11 lead referees were assessed during 29 Rugby World Cup (Knockout and Pool) matches. Average speed and heart rate

were assessed using rolling average methods (1-10 min epochs). Linear mixed models and Cohen's effect size (d) were used to compare match variables between Pool and Knockout matches. **Results:** Referees covered on average 6674 ± 566 m (65.8 ± 6.3 m·min⁻¹), with 586 ± 290 m in high-speed running. Mean heart rate was 146 ± 9 beats·min⁻¹, summated heart-rate-zones was 235 ± 36 AU, and sRPE load was 577 ± 205 AU. A large reduction (d=1.40) in high-speed running distance and moderate reductions in average speed over 1 (d=0.81) and 2 min (d=0.83) epochs were found during Knockout, compared to Pool matches. Differences between Pool and Knockout matches on other measures of referee movement, heart rate and RPE were *trivial*. **Discussion/Take home message:** This is the first investigation to examine the effect of competition stage on rugby union referees on-field performance. Individual and match contextual factors may explain the reduction in high-speed running during Knockout matches, however more detailed examination of the factors influencing referee

performance is required for greater insight into the key performance indicators in rugby union. Nonetheless, these data provide practitioners with knowledge to assist in preparation of rugby union referees for future Rugby World Cup competitions.

23. Cold-water immersion of the arms as a cooling strategy during repeated sprint exercise.

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Introduction: Full-body cold-water immersion is the best method of core heat conduction, however, practical strategies such as using cold-water immersion of the arms (CWA) has received little consideration. **Method:** Fifteen non heat-acclimated, recreationally trained participants (5 male) completed two Wattbike™ repeated sprint interventions using a randomised cross-over design in a heated laboratory environment (~30-32°C, ~55-65% RH). The protocol consisted of a 19-min controlled intensity warm-up, followed by two 7-min halves (H1, H2) designed to replicate the physiological demands of rugby sevens, whereby participants completed six 6s maximal effort sprints per half. Participants either performed CWA for 60s after the warm-up and during half-time, or a passive control. Tympanic temperature (T_{TYMP}), heart rate (HR), perceived exertion (RPE), thermal sensation (TS), thermal comfort (TC), peak power (PPO) and mean power output (MPO) were collected throughout each test. **Results:** CWA decreased T_{TYMP} during H2 ($p < 0.01$, $d = -0.59 \pm 0.34$), while CWA decreased TS during H1 ($p < 0.01$, $d = -0.55 \pm 0.32$) and H2 ($p = 0.06$, $d = -0.36 \pm 0.31$) and improved TC during H2 ($p = 0.05$, $d = -0.36 \pm 0.31$). In the first sprint after half-time, both MPO and PPO were greater in CWA (43 W, $d = 0.21 \pm 0.21$; 47 W, $d = 0.21 \pm 0.20$; both $p = 0.08$, respectively). There were no differences in HR or RPE between CWA and control at any measurement point. **Discussion:** CWA was effective at improving the T_{TYMP} and perceptual response to repeated maximal efforts in the heat, along with marginal gains in performance immediately after half-time. This may provide a practical pre- and/or per-cooling strategy for athletes competing in a hot/humid environment, which may be particularly relevant to athletes with minimal time to conduct other more common cooling methods. **Take home message:** When completing a repeated sprint simulated sevens protocol in the heat, 60-s of CWA post warm-up and at half-time can improve physiological, perceptual and performance outcomes.

24. Comparing the effectiveness of 9-day passive vs. active heat acclimation

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Introduction: Human cardiovascular and thermoregulatory systems can be powerfully adapted through repeated bouts of hyperthermia, known as heat acclimation, potentially improving health outcomes and exercise performance. However, it is not clear whether passive or active heat acclimation is more effective. The purpose of this study was to compare the effectiveness of 9-day passive vs. active acclimation. **Methods:** Seven endurance-trained participants (23 ± 4 y; 2 female; $\dot{V}O_{2peak}$ 59 ± 8 ml/min/kg) completed one active and one passive 9-d ($60 \text{ min} \cdot \text{d}^{-1}$) acclimation regime in randomised order, separated by at least 6 weeks. The active regime took place in a heat laboratory (40°C ; 50% RH) whilst cycling, and the passive regime in a spa bath (40°C) whilst sitting. **Results:** Both modes of acclimation successfully induced classic heat adaptations. Both modes increased resting plasma volume (spa, $5.4 \pm 6.8\%$; ex, 5.8 ± 5.3) and decreased resting core temperature (spa, $-0.2 \pm 0.2^\circ\text{C}$; ex, -0.3 ± 0.3) (all $p \leq 0.05$) to a similar extent (both $p \leq 0.52$). Only spa acclimation reduced resting mean arterial blood pressure (spa, -15 ± 7 mm Hg; ex, 0 ± 5 ; $p \leq 0.01$). During acclimation sessions thermal sensation was similar between regimes ($p = 0.14$), but thermal discomfort was lower and affect higher in spa (-0.6 ± 0.4 ; -1 ± 0.4 , respectively; both $p \leq 0.01$). **Discussion:** Both active and passive acclimation regimes were effective, yet resting blood pressure adaptations were present only following spa; we speculate this may be due to greater vascular antegrade shear stress by virtue of the hydrostatic pressure of immersion. **Take home message:** Choice of mode of heat acclimation may depend on desired adaptations, i.e., spa may be more effective for blood pressure reduction and feel better than exercise-based acclimation.

25. Determining the role of exercise-induced heat and upper limb sprint interval training on metabolic function

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Introduction: Heat alone elicits exercise-related cardiovascular and metabolic adaptations as well as when apart of exercise. Exercise itself is highly heat stressful via the muscle generated heat of metabolism, though it has not been studied whether this heat is a necessary part of stimulus for metabolic adaptation. The purpose(s) of this study were therefore to i) investigate the effects of tissue temperature elevations on indices of metabolic fitness and ii) investigate the impact of upper-limb sprint interval training on glycaemic control. It was hypothesised that i) training without normal elevations in muscle temperature would

blunt adaptations to exercise and that ii) sprint interval training would improve glycaemic control. **Methods:** Seven physically-active participants (3 females) completed the 2-wk training intervention as well as pre and post testing. Participants had one arm randomised to train normally (WARM) and one cooled (COLD) by immersion in $\sim 8^{\circ}\text{C}$ water for 10 min before exercise and between bouts. Exercise consisted of six 30-s maximal exercise bouts with 4-min recovery. Testing included a single-arm incremental test and a five-minute functional capacity test, during which metabolic indices were measured. **Results:** Muscle temperature in the biceps brachii was successfully maintained at below or at baseline for the COLD whereas temperatures increased by 2°C ($p = 0.009$) for the WARM condition. Regardless of the increases in temperatures there appeared to be no significant differences ($p \geq 0.181$) between conditions during the pre or post testing, with significance found only for perceptual measures (i.e., RPE) ($p = <0.001$). **Discussion:** This study demonstrated the feasibility of a research model to study effects of exercise-induced elevations in skeletal muscle temperatures. The 2-wk training intervention did not show an effect. **Take home message:** A longer training period, large sample size as well as more invasive measures of metabolic indices are required to determine the effects of heat during upper-limb SIT.

26. Regulation of brain oxygen delivery in hypoxia: the effect of acclimatization

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Introduction: Appropriate oxygen delivery to the brain is critical for human function. As such, cerebral oxygen

delivery (CDO_2) is meticulously regulated by several interconnected mechanisms. We sought to quantify the role of each component involved in regulating CDO_2 across vastly different durations of hypoxic exposure. **Methods:** Oxygen saturation, haemoglobin concentration ([Hb]) and cerebral blood flow (CBF) were measured in 16(7F) participants in normoxia at sea-level, after 10 min of acute hypoxia, and after 16 days residing at 4330m. The same measures were collected in a cohort of 16 age- and sex-matched high-altitude natives at 4330m. A subset ($n=8$) of these high-altitude natives with excessive erythrocytosis underwent isovolaemic haemodilution to match the [Hb] of lowlanders. **Results:** Acute hypoxia at sea-level reduced arterial oxygen content (CaO_2) from 19.2 ± 0.5 to $16.8 \pm 0.8 \text{ mL/dL}$ ($p < 0.01$); however, a compensatory 4% increase in CBF maintained CDO_2 ($p=0.94$). Sixteen days at 4330m increased haemoglobin concentration from 14.3 ± 0.4 to $16.4 \pm 0.5 \text{ g/dL}$ ($p < 0.01$), restoring CaO_2 to sea-level values despite an oxygen saturation of $87 \pm 3\%$. In these lowlanders, CBF and CDO_2 were each slightly reduced by 10% ($p=0.04$). In comparison, high-altitude natives had higher [Hb] ($19.0 \pm 2.7 \text{ g/dL}$; $p < 0.01$) and CaO_2 ($p < 0.01$), but CBF was 14% lower. Together, CDO_2 was similar between lowlanders and highlanders (138 ± 26 vs $132 \pm 37 \text{ mL O}_2/\text{min}$, respectively; $p=0.18$), albeit via different mechanisms. Isovolaemic haemodilution decreased [Hb] from 22.1 ± 1.7 to $19.7 \pm 1.7 \text{ g/dL}$ ($p < 0.01$) and CaO_2 from 22.5 to 19.1 mL/dL ($p < 0.01$) and caused a compensatory 22% increase in CBF ($p < 0.01$), which was sufficient to maintain CDO_2 ($p > 0.05$). **Discussion:** Acute changes in CaO_2 , whether caused by reductions in oxygen saturation or [Hb], are sufficiently accommodated by changes in CBF to maintain stable oxygen delivery to the brain. **Take home message:** The cerebrovasculature is sensitive to changes in both oxygen saturation and [Hb], supporting the notion that CDO_2 is the primary regulated variable in resting humans.

Injury Preventions

27. Are there any differences in the shoulder muscle strength and range of motion between cricket fast bowlers with and without shoulder pain?

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Introduction: Structural anatomical adaptations to the stabilising soft tissues of the shoulder has been associated with long-term exposure to repetitive cricket bowling and throwing. Changes to the glenohumeral range of motion (ROM) and isometric muscle strength (IMS) has associated with cricketer's shoulder pain. Hence, a comparison of the shoulder's rotational ROM and IMS was conducted between cricketers with and without shoulder pain. **Methods:** During the 2018 New Zealand cricket season 26 male club-level fast bowlers (24.2 ± 5.7 y, mass 82.3 ± 8.4 kg, height 1.84 ± 0.09 m), voluntarily participated in the study. All the

participants were objectively screened for the presence of shoulder pain and allocated either to a ($n=9$) shoulder pain group (SPG) or a ($n=17$) healthy shoulder group (HSG). Bilateral shoulder rotational ROM, IMS and posterior shoulder tightness were measured for both groups. **Results:** During the testing, pain was elicited on the dominant bowling shoulders of nine (35%) fast bowlers; none of the participants reported shoulder pain on their non-dominant side. There were no significant differences in the ROM, IMS and posterior shoulder tightness between the groups. Bowlers with shoulder pain had non-significantly slightly lower ROM on their dominant shoulder's internal rotation ROM, (SCG; $76 \pm 8^{\circ}$, HSG; $79 \pm 9^{\circ}$, $P < 0.44$), and external rotation ROM (SCG; $81 \pm 12^{\circ}$, HSG; $86 \pm 5^{\circ}$, $P < 0.25$). **Discussion:** While the bowlers with painful shoulders exhibited a slight trend of lower ROM on the dominant shoulders, it did not reach a statistical significance. This suggests that although ROM and IMS assessments can help

measure shoulder joint's anatomical changes, they alone cannot identify a shoulder joint at injury risk. **Take home message:** Cricketers tend to ignore shoulder pain and continue playing, subjective reporting and objective assessment of shoulder pain is necessary to identify players at injury risk and to modify training accordingly.

28. Benchmarking calf muscle power and endurance in rugby athletes using the *Calf Raise* app

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Introduction: Soft-tissue injury claims are the most common in New Zealand rugby (76%). Over a third of these claims involve the leg, knee, or ankle regions. There is a considerable risk of calf muscle and Achilles tendon injury in rugby. Despite the various calf muscle testing procedures used in research and practice, there is a lack of normative data for athletes. **Methods:** Ninety-two (79 males, 13 females) competitive rugby athletes performed bodyweight power, weighted power, and calf-raise endurance tests on a step once each with their dominant and non-dominant legs.

Data were extracted using the novel *Calf Raise* application. The effect of sex and leg dominance on outcomes was assessed using generalised estimation equations. A subset of 18 males completed test-retest reliability. **Results:** Reliability was acceptable across the key outcome measures (coefficients of variation $\leq 10\%$, intraclass correlation coefficients ≥ 0.83). Females were significantly less powerful than males in both bodyweight (465 ± 75 vs 679 ± 135 W) and weighted (438 ± 84 vs 677 ± 164 W) power tests. Despite a similar median number of repetitions (21.5 vs 20) and total concentric displacement (196 ± 48 vs 206 ± 66 cm), work performed (1363 ± 42 vs 1993 ± 581 J) during the endurance test was lower in females. There were no significant differences between dominant and non-dominant legs across measures. **Discussion:** This study provides insight on calf muscle function in competitive rugby athletes. The procedures used highlight the importance of not only considering the number of repetitions when assessing endurance. Increasing the database will enable sex-specific benchmarking of calf muscle power and endurance measures across rugby levels and by codes. **Take home message:** Sex-specific normative values are warranted in assessing calf muscle power and endurance in rugby. The testing battery and *Calf Raise* outcomes were reliable between test sessions.

Health & Sports Medicine

29. Using a motor analogy to promote safe-landing from unexpected falls

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Introduction: Accidental falls can cause significant health problems among older adults, including frailty, immobility, and decline in functional ability. Previous research into self-initiated falls implies that motor analogies can help people land more safely when falling, reducing the risk of injury. However, falls often occur unexpectedly and the efficacy of motor analogies for unexpected, rather than self-initiated, falls is unknown. **Method:** Thirty young adults were randomly allocated to an analogy or control group. Participants adopted a quiet standing position and a 'nudge' was applied to their shoulder unexpectedly causing a fall in one of four randomized directions (backward, forward, left-side, right-side). The analogy group was instructed to "land like a feather", whereas the control group was instructed to "land safely". Acceleration data (g) were extracted from thirteen inertial measurement unit sensors attached to different body segments and Fracture Risk ratios (FR, defined as the ratio of force at impact divided by the load necessary to cause a fracture) were calculated based on the hip and wrist sensors. **Results:** The analogy group displayed significantly lower maximum acceleration at ground contact in their upper extremities (arm, wrist, hand sensors: 9 to 13% reduction) and lower extremities (thigh, leg sensors: 6 to 10% reduction) compared to the control group (p -values

< 0.05), but not in the head or trunk (p -values > 0.05). Additionally, the analogy group displayed significantly lower wrist FR ratios (11 to 17% reduction) compared to the control group (p -values < 0.05). **Discussion:** A common landing strategy during unexpected falls is to employ the extremities to reduce the risk of injury to the trunk, head, and important body organs, which in turns increases the likelihood of extremity fractures. Our findings suggest that analogy instructions may reduce the likelihood of injuring the extremities, especially the upper extremities, without increasing the risk of head and trunk injuries. **Take home message:** A relevant motor analogy has the potential to promote safe landing and reduce the risk of injury during accidental falls. Further research is needed to establish the efficacy of this approach for reducing fall-related injuries in older adult populations.

30. Expanding the RED-S model: a mixed-methods approach to elite male and female track cyclists with varying levels of energy availability

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Introduction: Relative Energy Deficiency in Sport (RED-S) is a complex syndrome, caused by low energy availability (LEA). However, current RED-S research typically operates in two distinct disciplines—the physiological (quantitative) and the socio-psychological (qualitative). Therefore, a mixed-method research approach will contribute to a greater

understanding of RED-S and thus expand on the RED-S model. **Method:** Physiological and socio-psychological data were obtained from 15 (10F, 5M) elite track cycling athletes. Physiological data consisted of energy availability (EA), blood hormone analysis, bone mineral density (BMD) and body composition. Socio-psychological data consisted of individual semi-structured interviews. Athletes were compared between LEA (<30 kcal/kg of fat-free mass/day) and higher energy availability (HEA; > 30 kcal/kg of fat-free mass/day) using independent t-tests. Interview data were analysed following thematic analysis. **Results:** Athletes categorized as having LEA was 67% and 93% of athletes reported normal BMD. No differences were observed in blood hormone levels or BMD between EA categories ($p > 0.05$). EA and dietary intake were significantly lower in athletes with LEA compared to athletes with HEA ($p = 0.000$ and $p = 0.002$, respectively), that contributed from a reduction in carbohydrate and fat macronutrients. The interviews showed that nutritional practices in reducing carbohydrate, and athlete body image perceptions were not dependent on EA category. Knowledge of RED-S and the impact on health and performance was minimal and only known by female athletes who had experienced RED-S related consequences. **Discussion:** This study demonstrates the advantage of conducting a mixed-method approach in understanding RED-S. The interviews provided greater understandings of the pressures, perceptions and nutritional practices that impacted the physiological findings. **Take home message:** RED-S is a complex syndrome therefore, to gain a greater understanding of the complexities; it is proposed that research implementing mixed-methods are conducted.

31. Rugby Fans in Training New Zealand (RuFIT-NZ): a randomised controlled trial of a healthy lifestyle program for overweight men delivered through professional rugby clubs in New Zealand

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Introduction: Men's health statistics are a significant issue, particularly with respect to levels of obesity. New approaches are necessary that will engage, motivate and empower men to improve their health behaviours. Rugby Fans in Training-New Zealand (RUFIT-NZ) is an evidence-based, gender-sensitised healthy lifestyles programme delivered through professional rugby franchises. This study reports the effectiveness of RUFIT-NZ. **Method:** A pragmatic, two-arm, multi-centre, randomized controlled trial was conducted in 3 NZ clubs. 378 men aged 30–65

years with BMI ≥ 28 kg/m² were randomised. 200 completed the trial (n=103 intervention; n=97 wait-list control), 178 could not complete due to COVID-19 and were excluded from analysis. The intervention-group participated in the 12-week RUFIT-NZ program consisting of once-weekly exercise sessions, alongside workshop-based education sessions focused on healthy lifestyle topics. The primary outcome was change in body weight (CBW) from baseline to 52 weeks. Secondary outcomes were waist circumference, blood pressure, fitness, and lifestyle behaviours at 12 and 52 weeks. Data were analysed using generalised linear regression, adjusted for stratification factors under the intention to treat principle. **Results:** At 52 weeks, the mean difference in CBW between the groups was -2.77 kg (95% CI -4.92 to -0.61) in favour of the intervention ($p=0.01$). Significant intervention effects were also observed for body weight, BMI and adherence to lifestyle behaviours at 12 weeks; waist circumference, all fitness measures, self-reported physical activity and perceived health at 12 and 52 weeks. **Discussion:** RUFIT-NZ effectively supported men to lose weight and improve lifestyle behaviours and sustain those changes 52 weeks later. NZ European, Māori and Pacific men from across the age spectrum participated. Research should investigate the translation of RUFIT-NZ into public health practice. **Take home message:** RUFIT-NZ appealed to NZ men and participation resulted in men losing weight and improving their lifestyle behaviours up to one year later

32. The use of steady-state visual evoked potentials (SSVEPs) in concussion diagnosis and recovery assessment

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Introduction: Concussion diagnosis and assessment of recovery currently relies on subjective methods like self-reporting, questionnaires, and neuropsychological tests (either paper-based or computerized). The NUROCHEK system uses steady-state visual evoked potentials (SSVEP), which is a type of event-related potential (ERP), to assess neurophysiological activity with the ultimate goal of making a diagnosis of concussion and charting a course of recovery. **Method:** Fifty-one club or semi-professional rugby players in the Bay of Plenty (22 female and 29 male) completed two assessments with the NUROCHEK system and two error-free trials of the King-Devick test at three time points; pre-season (though the baseline was not always completed before contact practice began), mid-season, and post-season. Ten concussed athletes were tested within 3 days post injury, then again at 5, 10, 15, and 20 days post-injury. Recovery times were determined by K-D changes and reports from the team medical staff. **Results:** 43% of athletes (n = 22) had at least one previous concussion, and the mean age was 25.2. This study has elements of both an inter- and intra-reliability design; results from the concussed players were compared to the non-concussed players and to their own baselines. The effects of three demographic

factors associated with concussion (sex, age, and concussion history) were also examined. **Discussion:** Data analysis regarding the utility of the headset is in-progress, but general impressions are that athletes demonstrated several types of distinct EEG patterns or artefacts, that signal strength was often weakened after injury and became stronger as the athlete recovered, and that male athletes showed higher average SSVEP signal strength than female athletes at all time points. No differences were observed for age or history of concussion. **Take-home message:** SSVEPs (in conjunction with physician assessment) can be useful in identifying concussive damage and recovery.

33. The effect of passive heat therapy on body composition and isometric muscle strength in patients with severe lower-limb osteoarthritis

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Introduction: Osteoarthritis is a degenerative joint condition, characterised by reduced muscle strength, pain and impaired mobility. The knee and hip are the two most common sites, making traditional lower-limb weight-bearing exercise painful. The purpose of this study was to examine the effects of passive heat therapy (PHT) as an

exercise mimetic, compared to home-based exercise (HBE) on body composition and isometric muscle strength. **Methods:** This is a randomised controlled trial in which nineteen patients (12 female; age = 66 ± 8 y; body mass index = 32.1 ± 8.2 kg·m⁻²) scheduled for hip (n=9) or knee (n=10) arthroplasty were randomised to twelve weeks HBE (n=10; light-resistance exercises; 2 x 8-12 reps of 10 exercises; 3 x per week) or PHT (n=9; 20-30 min of warm-water immersion at ~40°C; combined with frequency matched post-immersion light-resistance exercises). Body composition (bioimpedance analysis) and isometric muscle strength of lower-limb muscle groups (with a hand-held dynamometer) were measured at baseline and end of intervention. Presented data are from a preliminary analysis; therefore no inferential statistics were performed. **Results:** Muscle mass increased in the PHT ($+2.1 \pm 4.2$ kg) and HBE ($+0.9 \pm 2.6$ kg) groups, while body fat percentage decreased ($-3.4 \pm 7.9\%$; $-1.8 \pm 5.0\%$). Knee extensor and flexor strength increased by 1-20% on the OA and non-OA sides with PHT, and 4-11% with HBE. Hip abductor and extensor strength increased by 13-32% on the OA and non-OA sides with PHT, but only hip abductor strength increased with HBE (14-32%). **Discussion and take-home message:** Twelve weeks of passive heat therapy or home-based exercise increased muscle mass, reduced body fat mass and increased isometric muscle strength in patients with severe lower-limb osteoarthritis. This may offer benefits in the prehabilitation of patients with severe lower-limb osteoarthritis.

Coaching

34. Considerations in developing adaptable and skilful athletes

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Introduction: How can coaches and sport scientists work collaboratively to develop adaptable and skilful athletes? In this presentation I will describe key principles of the Ecological Dynamics theoretical framework and suggest how they can be incorporated to help design more effective practice environments. I will refer to recent examples from water safety and climbing research to illustrate these principles. Learners need to be encouraged to explore representative practice environments that facilitate skill transfer to different competition environments. With the study of human movement now bridging many sub-disciplines, including motor development, psychology, biology, and physical therapy, the new textbook *Dynamics of Skill Acquisition* (Button et al., 2020: Second Edition)

presents a comprehensive model for understanding how coordination patterns are assembled, controlled, and acquired. **Take home message:** Coaches are practice designers who can unlock the capacity for athletes to become more adaptable and skilful **Additional Information:** To coincide with new textbook published in 2020. See discount information in conference pack.

www.booktopia.com.au/dynamics-of-skill-acquisition-2ed-chris-button/book/9781492563228.html

35. Community rugby coaches' perceptions and practices related to Small Blacks education programme and tools package: what are the barriers and facilitators to programme implementation?

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Introduction: Standardised structured warm-ups such as the FIFA U11 have been shown to successfully reduce injuries in young players. The success of this programme

has been linked to the buy-in from coaches and support for coach training. In 2018 New Zealand Rugby introduced a similar U13 warm-up strategy to the Small Blacks coach training programmes. The aim of the current project was to understand the extent to which the programme and tool package influences coaches' perceptions, behaviours and practices around warm-up strategies for this age group. **Methods:** A cross-sectional web-based survey design collected 860 responses from registered Small Blacks coaches (U5-U13). The design was adapted from Barengo et al., (2014) and Sadigursky et al., (2017) to the New Zealand Rugby landscape and Small Blacks programme specifically. Proportions of answers were calculated as percentages and open ended questions were categorised (1. Content of tool packages, 2. Coaches beliefs and attitudes). **Results:** 84% of respondents expressed a belief in the value of warm-ups for youth U13 prior to attending a Small

Blacks course and 60% believed injury prevention was the primary reason for performing warm-ups. 62% agreed that the Small Blacks programme changed the way they perform warm-ups with their team and 60% used all or the majority of the tools provided by NZR, which they found to be easy to use, while fun and engaging for the athletes. **Discussion/ Take home message:** These findings suggest that coaches of U13 players generally seem positive towards warm-ups and the specific tools offered by New Zealand Rugby. Most coaches have attended the Small Blacks coaching course that provides guidance and tools for warming up. However, it is evident that coaches may not understand the specificity of exercises and their intended injury preventive goal, although this was considered the coaches most important aspect of warming-up. Personal warm-up plans and unaware of the Small Blacks warm-up were justifications for not adopting this resource.

Sport Psychology

36. Influence of perceived opposition ability on exerted effort in junior footballers

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Introduction: In studying sport there has been an interest in what influences competitors both positively and negatively. Opposition ability has been shown to influence physical measures, yet opposition ability has only been measured objectively, and not based on an individual's perception. The purpose of this study was to investigate whether perception of opposition ability influenced the level of exerted effort in junior footballers. The hypothesis of this study is the higher the perceived opposition ability the higher the average and maximum heart rate will be. **Method:** A repeated measures design was used to gather data on six junior footballers over six games. Before every game each participant indicated their perception of the oppositions' ability on a five point Likert scale, average and maximum heart rate were recorded for the first ten minutes of each game using heart rate monitors. **Results:** Multiple regression and Analysis of Variance testing was conducted, the results showed that perceived opposition ability was a significant predictor of average and maximum heart rate. The results also showed significant differences in average and maximum heart rate across the different perceived opposition ability levels. **Discussion/Take home message:** These findings were consistent with previous research that used an objective measure of opposition ability. This study shows there is a relationship between perceived opposition and heart rate, to what extent or what is causing this relationship remains unclear. Future research should focus collect data on a wider range of variables, like an objective measure of opposition ability, possession percentage and time spent in opposition half, as well as perceived opposition ability to determine what variable or combination of variables create the best model for predicting of average and maximum heart rate.

37. Investigating the effect of colour during football penalty kicks: Retrospective analysis of professional football players

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Introduction: The colour red is theorised to be a testosterone-dependent signal of dominance and threat that can undermine the performance of an opponent. However, in previous research we found that a blue, not red, spectator background elicited avoidance motivation among *inexperienced* penalty-kickers in soccer, but not experienced penalty-kickers. To further investigate this effect of colour, we conducted a retrospective analysis of penalty kicks in professional soccer games between 2005 and 2020. **Method:** Like our previous study, we examined the effect of red, blue, and other spectator backgrounds on avoidance motivation. Avoidance motivation was indexed by the proportion of kicks towards the larger side of the goal (i.e., avoidance behaviour), since it reflected the tendency to choose the easier option to reduce likelihood of failure. **Results:** We found that the proportion of kicks towards the larger side of the goal was significantly greater for red and blue colour backgrounds compared to the other colour background (p 's < 0.046). **Discussion:** Possibly, red and blue elicited avoidance behaviour because they are colours

that represent dominant teams in soccer. Indeed, since 1993, winners of the English Premier Championship have all worn primarily red or blue team colours. Our findings align with Colour-in-Context theory, which suggests that colour can affect psychological functioning consistent with the meaning of the colour – colours that carry positive meanings evoke positive processes, such as approach motivation, while colours that carry negative meanings evoke negative processes, such as avoidance motivation. **Take home message:** In the case of soccer, red and blue might be associated with dominance and threat, which therefore elicits avoidance motivation among viewers/kickers. There are multiple avenues that we can explore to leverage the effect of colour in sports, as colour is ubiquitous and inevitable.

38. Impact of Covid-19 lockdown on the mental health of New Zealand tertiary students who participate in regular physical activity

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Introduction: A growing body of research suggests the inclusion of regular physical activity can have beneficial impacts on mental health. Previous research has focused mainly on clinical populations and those that have been clinically diagnosed with mental disorders. There is little literature on those without pre-diagnosed mental conditions and the benefits of physical activity. The March Covid-19 lockdown as a result of widespread community transmission would have been responsible for a shift in many tertiary students usual routine, including changing to online University, a decrease in social events and adjustment to the practice of exercise. This would have resulted in an increase in potentially developing mental health conditions including depression, anxiety and bipolar. The area of interest for my research project is the impact of Covid-19 lockdowns on mental health in tertiary students who regularly participate in physical participation. **Methods:** 61 participants took part in the study. The study involved two questionnaires that were self-reported and were interested in physical participation rates (SPAAMS) and mood state (POMS). Participants were asked to rate their mood during the Covid-19 lockdown as a result of either a change in exercise routine or deprivation of exercise. **Results:** Results showed that those that participated in regular exercise during the lockdown had lower Total Mood Disturbance (TMD) scores compared to those that did not participate in exercise. Low TMD scores on the POMS questionnaire indicate more stable mood profiles whereas high TMD scores are an indication of less stable mood profiles which can lead to developing mental problems. **Discussion:** Exercise routine differed a lot for many students as a result of the Covid-19 lockdown restrictions which indicated either students not partaking in exercise or having a very different exercise routine. Participation in exercise was an indication of stable mood profiles and good mental health in tertiary students. This was a result of the physiological and psychological benefits exercises brings upon individuals. **Take home**

message: Regular inclusion of exercise indicates stable mood profiles and good mental health.

39. Elite hockey performance: Examining the relationship between propensity for reinvestment and challenge and threat state

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Introduction: The theory of reinvestment suggests that individuals who have a higher propensity to consciously control their movements are more likely to display disrupted performance when they are highly motivated to perform effectively. It is possible that biopsychosocial model of challenge and threat contributes to understanding of reinvestment – individuals who see themselves as unable to cope with the task demands (i.e., a threat state) are more likely to reinvest compared to individuals who see themselves able to cope with the task demands (i.e., a challenge state). In this pilot study we, therefore, investigated the interaction between challenge/threat states and reinvestment to gain insight into their effects on performance. We monitored the performance of elite hockey players during an indoor hockey tournament and examined associations between propensity for reinvestment and self-perceived ability to cope with the demands of each game. **Method:** Ten elite hockey players completed the Movement Specific Reinvestment Scale (MSRS) prior to an indoor hockey tournament. Prior to each game, the challenge/threat state was measured using the Cognitive Appraisal Ratio (CAR). Individual performance during each game was assessed by an independent coach. Correlation analysis was conducted to examine the associations between performance, CAR and MSRS. **Results:** A significant positive correlation was evident between MSRS and CAR ($r=0.604$, $p=0.032$), whereas, a negative correlation was evident between MSRS and performance ($r=-.581$, $p=0.039$). No association was found between CAR and performance ($p>0.05$). **Discussion:** This pilot study suggested that a high propensity to consciously control movements (reinvestment) was negatively associated with performance by elite hockey players under tournament pressure. Unexpectedly, high CAR scores (e.g., a challenge state) were associated with greater propensity to consciously control movements, which might explain why challenge state was not positively associated with performance. Further studies with more participants are warranted. **Take home message:** Athletes with a high perceived ability to cope with the demands of competition may be more likely to consciously control their movements, which has potential to cause worse performance.

40. Response inhibition under physical and emotional stress

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Introduction: Elite athletes need to be able to control their actions and respond adaptively under conditions of high physical and emotional stress. The current study investigated how physical and emotional stress may interact to influence ‘response inhibition’ – i.e., the ability to wilfully stop or suppress on-going action. **Method:** Eleven healthy young adults ($M_{\text{age}} = 22.7$ years) performed an anticipatory response inhibition task whilst cycling for 2 x 30 minutes at light and vigorous intensity on a stationary bicycle ergometer (i.e., 60% HRmax vs. 86% HRmax). Using a switch mounted on the bicycle handlebar, participants responded to a rising indicator on a screen and were instructed to lift their finger off the switch as soon as the indicator reached a target line (i.e., Go-trials; 70% of trials) or to inhibit their lifting response if the indicator

automatically stopped rising before the target line (i.e., Stop-trials; 30% of trials). Across both physical stress conditions, emotional stress was manipulated by means of delivering mild electric shocks upon making task errors (i.e., threat of shock vs. no threat of shock). **Results:** Manipulation checks of physical and emotional stress showed that both manipulations were performed successfully. A marginally significant interaction effect showed that go-response accuracy was lower under threat of shock when cycling at light intensity ($p = 0.027$) but not at vigorous intensity ($p = .XXX$). A marginally significant effect of emotional stress showed that stop signal delays tended to be higher (reflecting improved response inhibition) under threat of shock as compared to no threat of shock ($p = 0.051$). **Discussion:** Preliminary results from this study indicate that performance contingent manipulations of emotional stress may improve response inhibition and reduce go-response accuracy as individuals prioritise stopping, particularly under low physical stress. **Take home message:** Physical and emotional stress interact to influence response inhibition.

Poster Presentations

1. A comparison of a six-second peak power test on a cycle ergometer with other tests of alactic performance in international rugby union players

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Introduction: The purpose of this study was to compare traditional tests of alactic power, and anthropometric data with the results of a 6-s peak power test on a cycle ergometer (Wattbike Pro, Nottingham Eng.) in international level Rugby players. Thirty-three international level male Rugby Union players participated in the study. **Method:** Participants completed a 6-s peak power test on a cycle ergometer, 20m sprint and maximum velocity, standing long jump, weighted CMJ (40kg), unweighted CMJ, back squat (3RM), and anthropometric assessments. All tests were completed in two sessions across a single day. Pearson's correlations were carried out to compare peak power output (PPO) and relative peak power output ($W \cdot kg^{-1}$) in the 6-s peak power test with the other tests. **Results:** A number of large and very large significant correlations ($p \leq 0.05$). Across the group there were significant correlations between PPO and lean mass ($r=0.68$) PPO and bodyweight ($r=0.62$), $W \cdot kg^{-1}$ and 10-m ($r=-0.67$), 20-m ($r=-0.65$), $W \cdot kg^{-1}$ and maximum velocity ($r=0.63$), $W \cdot kg^{-1}$ and Skinfolds ($r=-0.56$), $W \cdot kg^{-1}$ and Standing Long Jump ($r=0.54$), and $W \cdot kg^{-1}$ and CMJ ($r=0.53$). Various position-specific correlations for the Backs and Forwards were present. **Discussion:** These results are likely due a number of factors including similarity in exercise duration, energy systems requirements and similarities in muscle groups recruited. Differences between position groups may reflect the unique physical qualities players must possess to meet game demands specific to their position. **Take home message:** The study suggests that a 6-s cycle ergometer test is associated with sprinting and jumping; and may be an effective substitute test when sprinting or jumping is impossible. Further investigation is warranted to determine if the 6-s cycle test as an effective training tool for sprinting and jumping performance.

2. Differences in body composition and performance characteristics of male rugby players that went on to become professionals, compared to players that remained amateur

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Introduction: The aim of this study was to investigate which body composition and physical performance variables characterised players that advanced to professional teams (professionals) and how these variables changed over time compared to those that did not secure professional contracts (i.e. remained amateurs). **Methods:** Between-player differences in body composition, strength, speed, power and aerobic endurance in 83 male university rugby sport scholarship recipients from 2015-2019 were analysed using Proc Mixed in SAS. **Results:** When arriving for the first year of the program, forwards that went on to become professional rugby players later in their careers were older (0.4 ± 0.3 yr, mean \pm 95% CI), heavier (4.6 ± 2.5 kg) and stronger (range 6.2-16.4%) than forwards that did not gain professional contracts. Professional forwards were also slower at sprinting (range -2.7-2.9%) and had lower Yo-Yo IRT L1 scores (-10.8%) compared to amateur forwards when they first arrived. Backs that went on to become professional players later in their careers were taller (3.5 ± 1.8 cm), heavier (4.6 ± 2.4 kg) and faster over a 20m ($-1.9 \pm 1.7\%$) and 30m ($-1.7 \pm 1.6\%$) sprint, compared to amateur backs when first arrived on the program. Compared to amateurs, professional players had a smaller increase in body mass ($-4.2 \pm 2.0\%$) and greater improvement in sprinting (3.7, 2.8, 2.8% over 10, 20 and 30m) and Yo-Yo IRT L1 performance ($14.7 \pm 11.0\%$) over the 3 years training at university. **Discussion:** Characteristics that are likely to assist rugby players in becoming professionals include being older, heavier, taller and stronger. Compared to amateurs, players that went on to become professionals tended to improve sprint and endurance running performance over their 3 years of training while maintaining skinfold levels. **Take home message:** Physical prowess is important for potential professional rugby players.

3. Monitoring heart rate, heart rate variability, and subsequent performance in team-sport athletes receiving hypoxic or normoxic repeated sprint training

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Introduction: Repeated sprint training in hypoxia is a popular training regime, but careful monitoring is needed to avoid overtraining¹. This study aimed to determine whether heart rate variability (HRV) measures taken in the training period are associated with post-training running

performance in rugby players. **Methods:** Amateur club rugby players completed 3 weeks of twice-weekly repeated sprint training (cycling) in either hypoxia (RSH, $n = 9$; 20.3 ± 2.1 years; 77.1 ± 10.2 kg; 173.9 ± 4.9 cm; $F_{I}O_2$: 14.5%) or normoxia (RSN, $n = 10$; 22.0 ± 4.1 years, 88.3 ± 14.1 kg; 177.9 ± 5.4 cm, $F_{I}O_2$: 20.9%). Resting heart rate (RHR) and HRV were monitored during normoxic rest immediately before training. Pre- and post-training aerobic endurance (Yo-Yo Intermittent Recovery Level 1 (YYIR1)) and repeated sprint ability (RSA, running) were measured. **Results:** Compared to RSN, RSH demonstrated possibly lower HRV (natural log of the root mean square of successive difference, RMSSD): $-8.5, \pm 19.1\%$ and standard deviation of N-N intervals: $-11.5, \pm 25.0\%$; percent change, $\pm 90\%$ CL), and higher RHR ($3.2, \pm 4.7$ bpm) post-intervention. Week 3 RHR and HRV demonstrated strong, statistically significant correlations with post-intervention performances in YYIR1 (RHR: $-0.82, p = 0.02$; RMSSD: $r = 0.58, p = 0.17$; low frequency: high frequency ratio (LF/HF): $r = -0.85, p = 0.01$) and RSA (RHR: $r = 0.73, p = 0.06$; RMSSD: $r = -0.53, p = 0.22$; LF/HF: $r = 0.77, p = 0.05$) in RSH, but not RSN. **Discussion:** RSH likely intensified training resulting in reduced HRV, however, an absence in power reduction during training suggests overtraining was avoided. The stronger correlations between resting HRV and post-training performance in RSH may point to responders and non-responders to RSH². **Take home message:** RHR and HRV may be valuable tools for monitoring added stresses associated with RSH.

4. Performance in the 1.2 km shuttle run test reflects fitness capacities in rugby players

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Introduction: We examined the relationship between performance in the 1.2 km shuttle run test (Bronco) with the Multistage Run Test (MSRT) and Yo-Yo Intermittent Recovery Test Level 1 (Yo-Yo IR1) in rugby players. Additionally, we compared Bronco scores between playing positions and rugby codes. **Methods:** Data from professional male rugby players (23 rugby sevens and 133 rugby union) were analysed. All rugby sevens players performed the Bronco and MSRT, whereas rugby union players performed the Bronco and Yo-Yo IR1. The relationship between the Bronco and MRST or Yo-Yo IR1 was quantified using Pearson r with 95% confidence intervals, whereas differences between playing positions and codes were quantified using Hedges' g with 95% confidence intervals. **Results:** Correlations between Bronco and MSRT were large ($r = -0.57$ and $0.53, p < 0.01$), and between Bronco and Yo-Yo IR1 were very large ($r = -0.74$ and $0.71, p < 0.01$). Bronco scores were similar between rugby sevens backs and forwards, but moderately better for rugby union backs (Hedges' $g = -0.90$). Small to moderately better Bronco scores characterised rugby sevens compared to union players (Hedges' $g = -0.36$ to -0.99). **Discussion:**

Clear and significant correlations were observed between the Bronco with the MSRT and Yo-Yo IR1. The low shared variance observed between the Bronco and the two other tests, however, indicates testing scores are not interchangeable. The similar running activities of backs and forwards during professional rugby sevens matches might explain the similar testing results observed between playing positions. In contrast, the greater running demands of professional rugby union backs compared to forwards likely explain their better Bronco performance. The clear differences in Bronco performance between rugby codes highlight the different on-field demands of these codes. **Take home message:** These results support the utility of the Bronco to assess fitness in rugby players.

5. Infants' avoidance of drowning: the effect of locomotor experience and type of access way to bodies of water

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Introduction: Ramps used in swimming pools to access the water are designed with a shallow slope that affords locomotion for all, including babies. Locomotor experience has been linked to babies' avoidance of falling into the water from drop-offs. The present study investigated infants' avoidance of submersion when a sloped surface leads to deep water using a novel Water Slope paradigm. **Method:** Forty-three infants ($M_{age} = 10.63$ months, $SD = 1.91$), with crawling experience ranging between 0.3 and 8.2 months ($M = 2.38$ months, $SD = 1.77$), and 34 infants ($M_{age} = 14.90$, $SD = 2.18$ months), with walking experience ranging between 0.4 and 6 months ($M = 2.59$ months, $SD = 1.56$) participated in this study. **Results:** No association between babies' avoidance of submersion and self-produced locomotor experience was found in the Water Slope paradigm. Results also revealed a greater tendency of babies to reach the submersion point on the Water Slope paradigm than to fall over a sudden drop into deep water (i.e., the Water Cliff paradigm). **Discussion:** Collectively, these results indicate that with self-produced locomotor experience, infants become attuned to relevant perceptual information about threats posed by water cliffs, but locomotor experience does not teach them to perceive water as unsafe when it can be approached via a slope. Put another way, slopes may entice infants into water to a greater extent than water drop-offs. **Take home message:** An important implication for caregivers and pool designers is that sloped

access to deep water appears to increase the likelihood of infants engaging in drowning incidents.

6. Hamstrings injury incidence, risk factors, and prevention in rugby union players: A literature review

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Introduction: Hamstring strain injuries are one of the most common injuries in Rugby Union, representing up to 15% of all injuries sustained. Acute hamstring strains have the highest recurrence rate of any muscle injury. **Methods:** We conducted a systematic search of the literature in September 2020 to locate published peer-reviewed articles from PubMed, SPORTDiscus™, Web of Science®, and Scopus® e-databases. Studies included were original research conducted in Rugby Union that evaluated hamstring strength, hamstring strengthening interventions, and/or hamstring injury outcomes. **Results:** Twenty-four studies met inclusion. Twenty-one studies (87%) included male players; one, female players (4%); and two, both males and females (8%). Isokinetic testing was the most common method used to quantify hamstring strength and imbalances in Rugby Union; with data indicating that professionals are stronger than amateurs, and forwards are stronger than backs. There is, however, a lack of evidence supporting the utility of isokinetic-based measures to inform injury prevention and return-to-play decisions in practical settings. There is stronger scientific evidence to support the use of Nordic eccentric strength measures to inform practice, with eccentric strength measures and imbalances predicting new and recurrent injuries in Rugby Union. **Discussion:** The aetiology of hamstring strain injuries is multifactorial, with age, playing position, fatigue, previous injuries, running actions, strength imbalances, and lack of readiness to play identified as potential risk factors. As such, return-to-play and injury prevention programs should seek to combine multiple strategies. These strategies should include Nordic strength assessment and exercises, high-speed running routines, biomechanical assessment, and adequate warm-up routines. **Take home message:** Strengthening programs with Nordic exercises significantly increased hamstring strength measures and decreased imbalance ratios in male and female Rugby Union players. These programs and measures were associated with a significant reduction in hamstring injury incidence and severity in professional players, warranting their integration in practice.

7. Assessing the effectiveness of an online exercise program for Cerebral Palsy patients using 'Physitrack': A randomised controlled trial protocol

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Introduction: Cerebral Palsy (CP) children often receive exercise programs to assist in rehabilitation. Adherence to exercise programs is a necessary component to achieve exercise goals but can be challenging. With the severity of CP, the accessibility of technology show successful integrations in the field of rehabilitation. **Method:** This thesis evaluates the current literature for online exercise applications used with the CP population. It uses it to develop a Randomized Controlled Trial (RCT) protocol, which determines an online application's effectiveness for use with CP. The literature review searches and reviews three main areas: 1) exercises for CP, 2) online applications, and 3) Gross Motor Function Classification System. Data were analysed to determine the frequency, intensity, type, and duration of training that improves Gross Motor Function Measure (GMFM) outcomes among CP patients. **Results:** Eleven studies informed the training program and outcome measures in the RCT protocol. Exercises modalities performed by the experimental and control groups included; cardiovascular, musculoskeletal, and cardiovascular + musculoskeletal. The experimental group's primary outcome was against the control group, GMFM-88E, Visual Pain Analog Scale, grip strength, and caregiver adherence. The secondary outcome measure is cardiovascular versus musculoskeletal versus cardiovascular + musculoskeletal subgroups. **Discussion:** There is a lack of evidence supporting online applications, indicating a need for more research. There are various studies on the use of games through technology, such as virtual reality. Still, few studies evaluate applications used primarily for demonstrating exercises for replication into the real environment (as opposed to the virtual environment). This thesis could help with future directions in online applications for CP patients. **Take home message:** Please find a way to make exercise/physical activity cost-effective and engage for CP patients and their caregivers for a higher rate of motivation and adherence. This advice will help make exercise rehabilitation more accessible, and a healthier routine adheres.

8. Cerebral metabolism appears elevated in hyperthermic individuals while completing cognitive tasks during exercise

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Introduction: Cognition can be impaired during exercise in the heat, which could contribute to military casualties. To our knowledge, the independent role of elevated core temperature during exercise has not been determined. The aim of the current study was to evaluate effects of elevated core temperature on cognition during physically-encumbering, heated exercise, and to determine whether the perceptual cooling effects of menthol can preserve any deficit in cognitive performance. **Method:** Eight participants completed three trials in randomised order: One normothermic (CON) and two with elevated (38.5°C) core temperature, induced by prior immersion in neutral versus hot water. In the CON trial and one hot trial (HOT) a water

mouth-rinse followed each cognitive task during the trial, (HOT) while the other trial used a menthol mouth rinse (MENT). Participants walked on a treadmill in humid heat (33°C, 75% relative humidity) in military clothing, completing a cognitive battery while near-infrared spectroscopy (NIRS) was used to record oxygenated and deoxygenated haemoglobin content in the frontal cortex. **Results:** No differences in cognitive performance were observed between conditions. NIRS showed greater oxygenated haemoglobin tissue content in HOT and MENT compared to CON ($\Delta O_2Hb-deO_2Hb$: $2.3 \pm 4.5 \mu M$, $p < 0.024$), and lower deoxygenated haemoglobin in MENT than in CON or HOT ($p = 0.017$), suggesting higher brain metabolism during the more stressful conditions. **Discussion:** The lack of differences in cognitive performance suggests that a moderately elevated core temperature does not impair cognitive performance. However, differences in the NIRS data between these conditions indicates that cerebral metabolism may be elevated during hyperthermia to preserve performance. The effects of menthol are undetermined due to the lack of heat-mediated cognitive impairment. **Take home message:** During hyperthermia, an increased cerebral metabolism may help preserve cognitive performance.

9. Understanding work restitution to optimise intermittent exercise performance in cyclists

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Introduction: Intermittent high-intensity cycling stresses aerobic metabolism and the ability to tolerate homeostatic disturbances. Aerobic metabolism is rate limited and measured externally as the critical power (CP), whereas work above CP is capacity limited and expressed as the work prime (W'). The intermittent nature of cycling races permits power output to decrease temporarily below CP, which allows partial reconstitution of the W' (W'_{Rec}) and restoration of homeostasis. Collectively, the CP, W' , and W'_{Rec} estimates provide the parameters to predict exhaustion through the Skiba $W'_{BALANCE}$ model. W'_{Rec} is expected to be a critical performance determinant which varies significantly between individuals at intensities $<50 W$ below CP. Therefore, this study investigated W'_{Rec} at the key recovery intensities of cycling races. **Method:** CP and W' were estimated from 1, 4, and 10-minute time trials. W'_{Rec} rates were estimated from at least 4 high-intensity interval trials containing a final time to exhaustion (TTE) interval. While warm-up and interval intensities were constant across conditions, recovery intensity between intervals was varied producing conditions of 0, 25, 50, and 100 W below CP (D_{CP}). Differences in the TTE interval reveal the recovery potential presented as an exponential curve. **Results:** Preliminary data from a single participant (CP: 296 W; W' : 15 kJ; W'_{Rec} half-time (s) = $13550(D_{CP})^{1.016}$, $R^2 = 0.99$) aligns with previously reported W'_{Rec} rates

at intensities $>50 W D_{CP}$, but exceeds W'_{Rec} predictions at intensities $<50 W D_{CP}$. Additional data collected from a range of cycling levels (amateur to elite) will be presented. **Discussion:** This initial data demonstrates the utility of modelling methods to predict TTE during intermittent cycling. These data have the potential to inform pacing strategies relevant to team pursuit cycling performance. **Take home message:** Time to exhaustion during intermittent cycling can be predicted using the presented methods and the Skiba $W'_{BALANCE}$ model.

10. Designing football small-sided game design for sprinting: Which variables are most important?

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Introduction: Small-sided games (SSG) in soccer can elicit an array of physical demands while simultaneously developing technical and tactical abilities. A limited number of studies have investigated the sprint demands of SSG and how they are modified by the large number of possible prescriptive variables. **Method:** This study reports the relative peak sprint demands using 10 Hz GPS of a sample of 34 game-based soccer training exercises performed by a team of 20 high-level amateur players (mean age 26.7 ± 4.4 years). The effects of several prescriptive variables on relative peak sprint speed (PSS) were analysed using a linear mixed-effects model. **Results:** Relative pitch area was associated with a small increase in relative PSS (0.84, 95% CI 0.74, 0.94; $p < 0.001$) for each 10 m² per player, while game duration showed a similar positive effect (1.08, 95% CI 0.86, 1.30; $p < 0.001$) for each additional minute. Employing a scoring game-objective (10.19, 95% CI 7.75, 12.63; $p < 0.001$), compared to possession, and limiting ball touches permitted (4.78, 95% CI 2.13, 7.44; $p < 0.001$) were also associated with increased relative PSS. Including neutral players showed a negative effect (-2.7, 95% CI -5.32, -0.07; $p = 0.044$). Players sparingly reached speeds greater than 90% MSS in the sample (1.43%, 17/1243 observations). **Discussion:** Analysis of a diverse sample of SSG captured *in situ* showed players were unlikely to reach $>90\%$ MSS during these activities, however, several variables were associated with increases in peak running speed during SSG, consistent with previous research on running demands/physiological responses. **Take home message:** If optimising SSG design towards sprint or high-speed running training objectives, increasing the relative pitch area, using a scoring game objective, limiting the touches permitted and removing neutral players may be useful. However, when considering the possible increases in scale, relative pitch area may have the greatest effect.

11. FLOWpresso™ device improves subjective sleep and fatigue measures: a 6 week pilot study

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Introduction: Deep pressure stimulation therapy has previously been used to increase parasympathetic activity to elicit a relaxed and calming effect. The FLOWpresso™ is a novel device that delivers deep pressure stimulation combined with far infrared heat, with individually controlled chambers that inflate in a sequential cycle starting from the feet and moving up the legs to the torso, upper back, and arms. **Method:** A pilot study investigated the effects of weekly 40 min treatments of FLOWpresso™ on sleep and fatigue in stressed individuals free from contraindications (n=11) over a six week intervention period. Sleep (PROMIS Sleep Disturbance – Short Form) and fatigue (Modified Fatigue Impact Scale) were assessed via questionnaire with components of physical, cognitive, and psychosocial fatigue. All items are scaled so that higher scores indicated a greater degree of sleep disturbance or fatigue. **Results:** Average sleep scores improved from 26.1 to 18.9 over the six week intervention period. Specifically, T-score analyses showed that the percentage of individuals identified as having mild to moderate sleep disturbance decreased from 73% (8/11) to 9% (1/11). Overall fatigue was decreased by 62%, with improvements observed across all three fatigue components. **Discussion:** Given the known links between sleep and negative psychological well-being, as well as the widespread impact of psychological stress on the quality of life, and the onset of chronic physical disease, interventions that target sleep quality and psychological stress should be an integral part of public health strategies. Sleep has been also identified as an important component of recovery in sports and exercise science, thus the FLOWpresso™ may have benefits in this context. **Take home message:** A combination of mechanical deep pressure stimulation and far infra-red heating was effective at alleviating fatigue and improving subjective sleep quality.

12. Determining the role of exercise-induced heat in resistance exercise conditioning

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Introduction: Heating muscle has been shown to be able to prevent atrophy and produce hypertrophy, and cooling can attenuate hypertrophy, its molecular signalling and vascular adaptations. Yet, the specific role of intrinsic heat produced by resistance exercise in mediating training adaptations is unknown. The aim of this study was therefore to determine the extent to which exercise-induced heat underpins adaptations from resistance training. We hypothesised that resistance training with prevention of exercise-induced rises

in muscle temperature would attenuate hypertrophic and strength adaptation. **Methods:** Five healthy non-resistance trained participants (three females) completed a 6-week bicep curl resistance training programme using a contralateral limb-control design. Eighteen training sessions (6x4 repetitions at ~80% 1RM) were completed with one arm randomised to train in a cool state (“Cool”) and the other arm training with natural heat accumulation (“Warm”). Cooling was achieved through arm immersion in 14°C water for 10 min preceding the first exercise set and between each remaining set (~2 min each). **Results:** Total relative load lifted was the same between arms (p=0.256). Peak isometric torque increased in both arms, with no effect of condition (Warm: 11±11%; Cool 4±7%; time: p=0.033; condition: p=0.310). Bicep curl 1RM increased similarly for both conditions (Warm: 25±11%; Cool 26±11%; time: p<0.001; condition: p=0.891). Trivial changes were observed in arm composition. Cool training attenuated increases in peak twitch amplitude (Warm: 38±26%; Cool 2±7%; time: p=0.011; condition: p=0.016). **Discussion:** Preventing exercise-induced elevation in muscle temperature did not attenuate functional or structural adaptations to strength training, thereby indicating that muscle temperature lacks a key role or is redundant in strength adaptations. However, an attenuation of muscle contractile adaptations occurred in the muscle trained cool. **Take home message:** Preliminary data from this strength training regimen suggests that exercise-induced increases in muscle temperature played a negligible role in promoting resistance training adaptations.

13. The effect of a volunteer-led community-based exercise programme on health outcomes in patients with chronic obstructive pulmonary disease

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Introduction: Pulmonary rehabilitation improves health in chronic obstructive pulmonary disease (COPD), and community-based maintenance programmes led by health professionals maintain these benefits. However, it is not known if a volunteer-led community programme can maintain the benefits from pulmonary rehabilitation. Therefore, we investigated the effect of a volunteer-led exercise group on the health of COPD patients. **Method:** Non-attendees (n = 24) and attendees (n = 19) of a volunteer-led group, completed four questionnaires (anxiety and depression (HADS), COPD (CAT), health status (EQ-5D) and social connectedness), a sit-to-stand test, and blood oxygen saturation pre-and-post rehabilitation, and at a 1-2-year follow-up. A qualitative interview was also conducted at follow-up. **Results:** There were no significant differences (p = 0.11 to 0.82) at follow up between non-attending and attending groups for all measures. A within-group comparison also found attendees had significant increases for depression and CAT scores (~30%, p = 0.04 and 0.006) relative to post-rehabilitation measures, and all health variables had returned to pre-rehabilitation (baseline) levels.

In contrast, qualitative analysis showed positive themes for attending the group, with the most common benefit being engaging with others experiencing COPD. In social connectedness, non-attendees were less trusting of others while attendees did more volunteering. **Discussion:** Pulmonary rehabilitation was found to produce significant health benefits for COPD patients. However, improvements were not maintained by attending a weekly volunteer-led community exercise group. For example, attendee's quantitative health outcomes reverted to pre-rehabilitation levels for measures such as depression, despite participating in an exercise group and being more socially connected. Therefore, the effect of COPD on well-being may be far reaching even in motivated, engaged and socially active patients. **Take home message:** Future studies should evaluate a conjoint programme led by volunteers and supported by health professionals to determine if health benefits from pulmonary rehabilitation can be maintained in the community.

14. The effect of combined lactate and VO₂ max testing on elicited VO₂ max measurement

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Introduction: Athletic testing facilities and academic institutions commonly offer aerobic fitness assessments. The two most common fitness tests are lactate threshold (LT) tests and maximal aerobic power tests ($\dot{V}O_2\text{max}$); often both tests are completed in a single testing session for convenience. This study aimed to address whether completing a prolonged LT test prior to $\dot{V}O_2\text{max}$ testing compromises the individual's $\dot{V}O_2\text{max}$ estimation. **Methods:** Seven aerobically trained participants completed two running testing protocols: a combined protocol which consisted of a 5+ stage LT protocol (210 second stages with 30 seconds rest to allow lactate measurements) immediately followed by an incremental $\dot{V}O_2\text{max}$ test (30 second increments), and an incremental $\dot{V}O_2\text{max}$ only test (1 minute increments). Testing was carried out in two sessions one week apart. Verification tests were carried to ensure max was achieved on all occasions and if verification $\dot{V}O_2\text{max}$ was 3.5 mL/min/kg higher than test, the verification value was used. Respiratory analysis was completed using an online gas analysis system. **Results:** The LT test took 24-35 minutes to complete, the $\dot{V}O_2\text{max}$ only protocol took 8-12 minutes to complete. No significant difference was found between measured $\dot{V}O_2\text{max}$ (Combined protocol = 57.52 ± 9.76 mL/min/kg, $\dot{V}O_2\text{max}$ only = 58.32 ± 9.50 mL/min/kg, $p = 0.468$) or heart rate (Combined = 195 ± 7 bpm, $\dot{V}O_2\text{max}$ only = 193 ± 8 , $p = 0.295$) between test protocols. **Discussion:** These findings suggest that both protocols can be used to reliably measure VO₂ max in aerobically trained people. However, further work is needed to investigate this in untrained or larger populations or on other ergometers. **Take home message:** A combined lactate and $\dot{V}O_2\text{max}$ protocol has the advantage of reducing costs for athletes both financially and in terms of time required to carry out testing. These findings suggest

that carrying out testing in a combined manner does not compromise $\dot{V}O_2\text{max}$ measurements.

15. Relationship between conscious movement processing and response to cognitive load

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Introduction: Research has challenged the idea that postural control (a fundamental movement skill) is automatic, requiring minimal conscious information processing, as cognitively demanding secondary tasks have shown to disrupt balance. Here we examine the relationship between conscious processing of movements and postural control. **Methods:** Sixteen older adults (age 74 ± 8.1 y) attended four sessions where they completed three balance conditions: eyes open (EO), eyes open while counting backward in threes (Dual task: DT), and eyes closed (EC). Postural control (average velocity, ellipse size, and approximate entropy [ApEn]) was measured for 60 s at 150 Hz using a multi-axis force platform. The propensity for conscious processing of movements was assessed using the Movement Specific Reinvestment Scale (MSRS). **Results:** The average MSRS score was 29 (range 10-50). MSRS scores were negatively correlated with velocity (EO: $r = -0.660$, DT: $r = -0.659$, EC: $r = -0.867$), ellipse (DT: $r = -0.576$), and ApEn (EO: $r = -0.608$). There was also a negative relationship between the MSRS score and the difference in between ApEn in EO and DT ($r = -0.538$). **Discussion:** The participants with higher conscious movement processing scores exhibited smaller average velocity and ellipse, regardless of condition, and demonstrated less complex postural control in EO condition. Lower complexity has been linked to reduced ability to adapt to changes in the environment. Individuals with a high MSRS score were more susceptible to adopt an inefficient motor control strategy under cognitive load. Given the known links between i) cognitive load, exercise performance, and perceived exertion, and ii) balance and injury risk, interventions to mitigate conscious processing of movement may have important health and performance implications. **Take home message:** An individual's propensity for conscious processing of movement is related to balance metrics, the complexity of movement control strategy, and may mediate the effects of a cognitively demanding secondary task.

16. Determining the role of exercise-induced heat in upper-limb sprint interval training on cardiovascular adaptations

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Introduction: Due to the intricate nature of the stressors within exercise, there is much we do not know about what stimuli drive adaptation. In particular, the role of exercise-induced heat production is under examined. The aim of this study was to investigate the effect of preventing elevation in tissue temperature - via cold water immersion throughout training - on cardiorespiratory adaptations during a two-week sprint interval training (SIT) intervention of the upper limbs. We hypothesised that (i) removing exercise-induced heating throughout training would attenuate cardiorespiratory related adaptations, and (ii) the upper-limb SIT would induce significant cardiorespiratory related adaptations. **Methods:** Seven aerobically untrained (upper body) participants (3 female) have completed the two-week upper-body SIT protocol, in a within-subject design. Cool training was allocated to the dominant or non-dominant arm in a randomised fashion, with the other arm allocated to Warm (control) training. Training comprised of six sessions of 4-6 30-s bouts with 4-min recovery. An incremental exercise test for each arm was completed before and after the intervention to measure cardiorespiratory responses ($\dot{V}O_{2peak}$, heart rate and blood pressure). **Results:** Elevation in muscle tissue temperature was prevented in the Cool arm compared to the Warm arm during SIT (all $p < 0.001$). Cooling suppressed blood flow in the muscle being trained, as indicated by lower haemoglobin content in muscle during exercise ($p = 0.04$) and recovery ($p = 0.02$). However, training outcomes revealed no significant changes in $\dot{V}O_{2peak}$ from pre- to post-test and no significant differences between conditions. Likewise, cardiovascular parameters (e.g. heart rate and blood pressure) showed no significant differences from pre- to post-test. **Take home message:** A two-week upper limb SIT intervention did not significantly increase upper-limb aerobic power, and therefore neither was there any effect of the muscle's training temperature. It therefore remains unknown whether exercise-induced heat is obligatory or redundant in exercise-mediated cardiorespiratory adaptations.

17. Does 6-week plyometric training on sand, improve vertical jump height performance? A narrative review.

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Introduction: Plyometric training is one of the most widely used training mode by athletes and individuals to improve strength and power. This narrative review of five articles was conducted to establish the efficacy of short-term plyometric training on sand on jumping ability. **Methods:** A literature review search was conducted through Google Scholar and EBSCO Host databases for journal articles published between 2013 and 2020, using phrases “short term”, “plyometric training on sand”, “countermovement jump or vertical jump” and “athletes”. The search focused on short term intervention studies. Using a consort diagram, of the 271 results identified, 120 articles were screened through relevance of title and abstract, then further narrowed down to the five most relevant studies to be extensively analysed in this study. Effect sizes (ES) using Hedges “g” were calculated for vertical jump (VJ) in each article and the mean VJ across five articles. **Results:** All five articles reported improvements in vertical jump in the plyometric intervention on sand. Four articles reported large effect sizes >1.0 for vertical jump, while one article resulted in moderate ES of 0.63 and Mean ES = 0.99. **Discussion:** Plyometric training on sand allows power and strength adaptations that improve VJ due to the mechanisms such as better neural adaptations, leg muscle activation strategies, intramuscular coordination, and stretch reflex excitability. However, the type of exercises used in the program and the length of rest may also have an effect on the efficacy of the training. **Take Home Message:** Short-term Plyometric training on sand improves vertical jump performance and other performance parameters. Therefore, athletes competing in sports such as volleyball, should consider 6 weeks plyometric training on sand, in order to improve lower limb power.