Rugby Codes Research Group

e-Magazine

Issue 8 (March) 2020

Hume, P.A. and Wyatt, H. Editors.

We acknowledge the support of AUT Millennium and SPRINZ for hosting the publication of this e-Magazine.

RCRG website:
https://sprinz.aut.ac.nz/areas-of-expertise/interdisciplinary-research/rugby-codes

AUT SPORTS PERFORMANCE RESEARCH INSTITUTE NEW ZEALAND

AUT MILLENNIUM

Professor Patria Hume - e-Magazine Editor

Welcome to issue 8 of the Rugby Codes Research Group (RCRG) e-Magazine. The aim for the RCRG e-Magazine is to communicate advances in evidence-based knowledge and its practical application to the wider support network of rugby codes. In this issue we provide updates on work by members that has resulted in journal publications. We highlight the Brain Gauge which has been used in several studies by Dr Doug King and colleagues and is being used in a series of studies by students at AUT SPRINZ including Taylor Lee from Purdue University.

The Rugby **Codes** Research Group is an international network that has over 150 members from 10 countries who focus their research on performance improvement and injury reduction in the rugby codes (union, league, football, etc). The RCRG co-leaders work together to help achieve the aims of the RCRG:

- Professor Patria Hume (Founder of RCRG, AUT Professor Human Performance, Biomechanist, Kinanthropometrist, Injury prevention specialist, Injury epidemiologist)
- Dr Doug King (AUT SPRINZ Research Associate, Biomechanist, Kinanthropometrist, Injury Prevention specialist, Injury epidemiologist)
- Professor Lesley Ferkins (AUT staff, Sports Management specialist)
- Associate Professor Nic Gill (All Blacks Strength & Conditioning Coach, AUT Staff)
- Dr Matt Brughelli (AUT staff, Strength and conditioning specialist, Biomechanist)
- Dr Ken Quarrie (NZ Rugby Senior Scientist, AUT SPRINZ Research Associate, Biomechanist, Injury Prevention specialist, Injury epidemiologist)

We aim to provide the latest evidence-based knowledge from the literature informing best practice within the rugby codes taking a comprehensive account of all supporting factions. For more information including membership forms, see **https://sprinz.aut.ac.nz/areas-of-expertise/rugby-codes**

Mission

Holistic advancement of practice within the rugby codes via applied research.

Aims

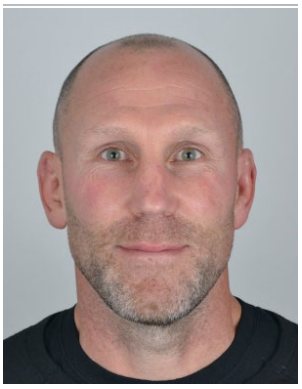
• Bring together expertise that integrates areas of sport research (injury prevention, strength & conditioning, sport technology, coaching, psychology, physiology, performance analysis, leadership, management).

• Offer leading edge design and development solutions to rugby organisations, teams and players around the world.

The Global Rugby **Health** Research Group aims to revolutionise how we prevent, identify and treat injuries that occur through participation in the rugby codes through connecting researchers, clinicians, patients / whanau, funders, policy makers and media. This group is led by Professor Patria Hume (New Zealand), Dr Doug King (New Zealand) and Dr Karen Hind (United Kingdom). This group developed from the World Rugby and NZ Rugby funded NZ RugbyHealth Research Programme. For more information see **https://sprinz.aut.ac.nz/areas-of-expertise/rugby-codes/global-rugby-health-research-programme**

RCRG e-Magazine contributions can be sent to:
AUT SPRINZ Research Fellow Dr Hannah Wyatt <hannah.wyatt@aut.ac.nz>

Mat Blair – MPhEd, BPhEd BSc Dip Tour



Experience: Principle Lecturer, Academic Leader - Postgraduate Diploma Applied Science (Physical conditioning), Otago Polytechnic.

Consultant for World Rugby High Performance.

Research overview: Matt's rugby research includes performance technology, wellness profiling and load measurement with sevens' players and match officials.

Postgraduate supervision:

Facilitator Master of Professional Practice (MPP)

Naca Cawanibuka (Fiji 7s Lead S&C) - The Fiji 7s Road to Gold - A Reflective Summary of the Fiji 7s Rugby Team Golden Journey at the 2016 Summer Olympic Games in Rio de Janeiro, Brazil (Current).

Semisi Fonua (Tonga Rugby Lead S&C) – Training Load and GPS Metrics for Ikale Tahi Leading into RWC 2019 (Current).

Lead Supervisor Master of Applied Science (MAS)

Jawad Al-attar – Original Scientific Research Study: Cohort Study – Training Load and its progression from amateur to semi-professional rugby (Completed).

Research publications:

Blair, M., Manuel-Hepi, N., Newman, L., Smith, T., & Elsworthy, N. (2019). Physical demands of international lead rugby union referees. *Journal of Australian Strength and Conditioning, 27*(03), 25-32.

Bester, C., Coetze, D., Schall, R., & Blair, M. (2019). Physical demands on elite lead rugby union referees. *International Journal of Performance Analysis in Sport*. doi:10.1080/24748668.2019.1593097

Blair, M., Elsworthy, N., Rehrer, N., Button, C., & Gill, N. (2018). Physical and physiological demands of elite rugby union officials. *International Journal of Sports Physiology and Performance*.

Blair, M., Cronin, J., Rehrer, N., Button, C., & Gill, N. (2018). Contextual review of physical requirements of refereeing rugby union at an elite level. *Journal of Strength & Conditioning, 40*(2), 17-30.

Blair, M., Body, S., & Croft, H. (2017). Relationship between physical metrics and game success with elite 7s rugby sevens players. *International Journal of Performance Analysis in Sport*.

Blair, M., Body, S., & Croft, H. (2017). The Physical metrics of world series sevens tournament matches. *Scope (Activity & Health), 1*. doi:10.1080/24748668.2017.1348060

Blair, M. (2017). Considerations for Rugby Sevens-specific training schedules. *Scope (Activity & Health), 1*.

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Consensus on a video analysis framework of descriptors and definitions

Video Analysis Consensus group: Sharief Hendricks, Kevin Till, Steve den Hollander, Trevor N Savage, Simon P Roberts, Gregory Tierney, Nicholas Burger, Hamish Kerr, Simon Kemp, Matthew Cross, Jon Patricios, Andrew J McKune, Mark Bennet, Andy Rock, Keith A Stokes, Alex Ross, Clint Readhead, Kenneth L Quarrie, Ross Tucker, Ben Jones

Using an expert consensus-based approach, a rugby union Video Analysis Consensus (RUVAC) group was formed to develop a framework for video analysis research in rugby union. The aim of the framework is to improve the consistency of video analysis work in rugby union and help enhance the overall quality of future research in the sport. To reach consensus, a systematic review and Delphi method study design was used.

What is already known?

►► Video analysis research beyond the scope of performance has grown in the last 10 years.

►► In video analysis studies, descriptors and definitions have either been lacking or inconsistent between studies.

►► Video analysis can be linked to injury surveillance data and directly used as part of an injury prevention strategy.

After a systematic search of the literature, 17 articles were used to develop the final framework that described and defined key actions and events in rugby union (rugby). Thereafter, a group of researchers and practitioners with experience and expertise in rugby video analysis formed the RUVAC group. Each member of the group examined the framework of descriptors and definitions and rated their level of agreement on a 5-point agreement Likert scale (1: strongly disagree; 2: disagree; 3: neither agree or disagree; 4: agree; 5: strongly agree). The mean rating of agreement on the five-point scale (1: strongly disagree; 5: strongly agree) was 4.6 (4.3–4.9), 4.6 (4.4–4.9), 4.7 (4.5–4.9), 4.8 (4.6–5.0) and 4.8 (4.6–5.0) for the tackle, ruck, scrum, line-out and maul, respectively.

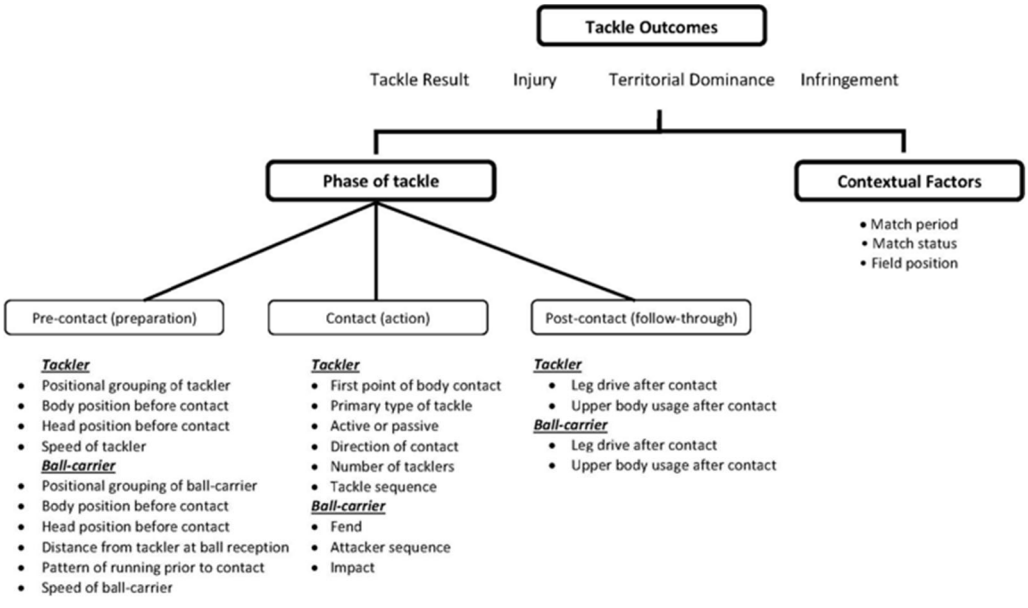

Figure: Video analysis model for the tackle

What are the new findings?

►► A consensus on a framework of descriptors and definitions for video analysis in rugby.

►► The framework focuses on key actions and is versatile across video analysis objectives.

The RUVAC group recommends using this consensus as the starting framework when conducting rugby video analysis research. Which variables to use (if not all) depends on the objectives of the study. Furthermore, the intention of this consensus is to help integrate video data with other data (eg, injury surveillance).

Meet Brain Gauge

compoundlabs
Healthcare uniquely you

The Brain Gauge system is a novel brain health assessment system that takes advantage of the well-documented relationship between the sensory nerves in the fingers and the projection of those nerves to corresponding regions in the brain.

Fig.1 The Brain Gauge Device and Software package

Brain Gauge is a small computer-mouse-shaped device with two buttons that can vibrate and detect movements with high resolution. It is so sensitive that it can measure the most-subtle changes in brain function and probe cortical function and utilize its complexity to gain more sensitive and specific detection of compromised neural function. The design integrates 50+ years of neuroscience research and over a decade of technology development.

When two of your fingers are touched or pulsated, two nearby corresponding regions in the brain become active and communicate with each other. Your ability to ascertain specific aspects of physical sensations, such as vibration intensity, duration, and order, is indicative of your brain's performance. Brain Gauge measures this to show how well your brain cells communicate.

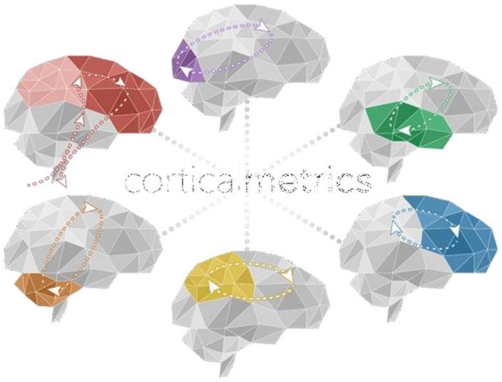

Fig.2 The parts of the brain that the Brain Gauge tests

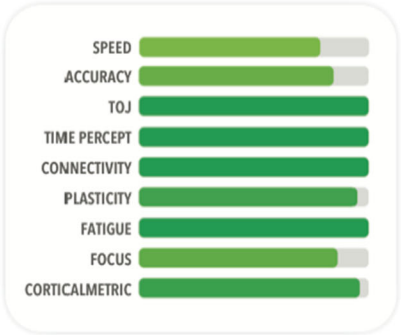

Fig.3 The Brain Gauge scoring metrics

The result is a measure 8 essential components of brain health: Speed, Focus, Fatigue, Accuracy, Sequencing, Timing Perception, Plasticity, and Connectivity. You also get a comprehensive mental fitness score that is called your 'corticalmetric'.

This enables you to track progress across a wide range of conditions, such as recovering from a brain injury resulting from Traumatic Brain Injuries/Concussion etc, keep tabs on conditions like neurological conditions such as Parkinson's and Alzheimer's and developmental issues in children around ADHD and Autism - and see how your brain responds to new treatment protocols or medications.

Email braingauge@compoundlabs.co.nz for more information, we'd be happy to help.

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IOC statement: methods for recording and reporting of epidemiological data on injury and illness in sports 2020

International Olympic Committee Injury and Illness Epidemiology Consensus Group: Roald Bahr, Ben Clarsen, Wayne Derman, Jiri Dvorak, Carolyn A. Emery, Caroline F. Finch, Martin Hägglund, Astrid Junge, Simon Kemp, Karim M. Khan, Stephen W. Marshall, Willem Meeuwisse, Margo Mountjoy, John W. Orchard, Babette Pluim, Kenneth L. Quarrie, Bruce Reider, Martin Schwellnus, Torbjørn Soligard, Keith A. Stokes, Toomas Timpka, Evert Verhagen, Abhinav Bindra, Richard Budgett, Lars Engebretsen, Uğur Erdener, Karim Chamari

Background: Injury and illness surveillance, and epidemiological studies, are fundamental elements of concerted efforts to protect the health of the athlete. To encourage consistency in the definitions and methodology used, and to enable data across studies to be compared, research groups have published 11 sport- or setting-specific consensus statements on sports injury (and, eventually, illnesses) epidemiology to date.

Objective: To further strengthen consistency in data collection, injury definitions, and research reporting through an updated set of recommendations for sports injury and illness studies, including a new Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) checklist extension.

Methods: The IOC invited a working group of international experts to review relevant literature and provide recommendations. The procedure included an open online survey, several stages of text drafting and consultation by working groups, and a 3-day consensus meeting in October 2019.

Results: This statement includes recommendations for data collection and research reporting covering key components: defining and classifying health problems, severity of health problems, capturing and reporting athlete exposure, expressing risk, burden of health problems, study population characteristics, and data collection methods. Based on these, we also developed a new reporting guideline as a STROBE extension—the STROBE Sports Injury and Illness Surveillance.

The figure demonstrates an effective way to communicate the overall burden (and its determinants) for a range of health problems.

Conclusion: The IOC encourages ongoing in- and out-of-competition surveillance programs and studies to describe injury and illness trends and patterns, understand their causes, and develop measures to protect the health of the athlete. The implementation of the methods outlined in this statement will advance consistency in data collection and research reporting.

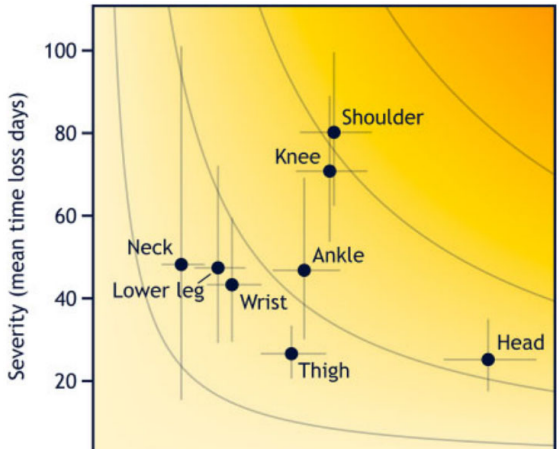

Figure: Risk matrix based on the duration of time loss illustrating the burden of match injuries among professional rugby teams in New Zealand between 2005 and 2018 (unpublished data). The darker the yellow, the greater the burden. The curved gray lines represent points with equal burden. The vertical and horizontal error bars represent 95% CIs.

Neurovascular Coupling in Retired Rugby Players

Sharma, A., Hind, K., Hume, P.A, Sungh, J. & Neary, J.P. (2020)

Aim: This study investigated cerebral hemodynamic responses to a neurovascular coupling (NVC) test in retired contact athletes with a history of repeated mild traumatic brain injury (mTBI) and in controls with no history of mTBI.

Methods: Twenty-one retired rugby players (47.7 ± 12.9 year old; age at retirement: 38.5 ± 8.9 year; number of years playing rugby: 12.7 ± 3.7 year) with a history of three or more diagnosed concussions (8.9 ± 7.9 concussions per player) and 23 controls with no history of mTBI (46.5 ± 12.8 year old) performed a NVC test to detect task-orientated cerebral hemodynamic changes using functional near-infrared spectroscopy (fNIRS).

Results: The NVC showed a statistically significant reduction in the cerebral hemodynamic response in comparison to the control group which had a greater relative increase of oxyhemoglobin (O2Hb, Figure). There were reductions in left middle frontal gyrus (MFG) O2Hb (−0.015 ± 0.258 µM) and relative increases in deoxyhemoglobin (HHb; −0.004 ± 0.159 µM) in the same region for the mTBI group in comparison to the control group (−0.160 ± 0.311 µM; −0.121 ± 0.076 µM for O2Hb and HHb, respectively). The mTBI group induced a greater rate of oxygen extraction compared to the control group.

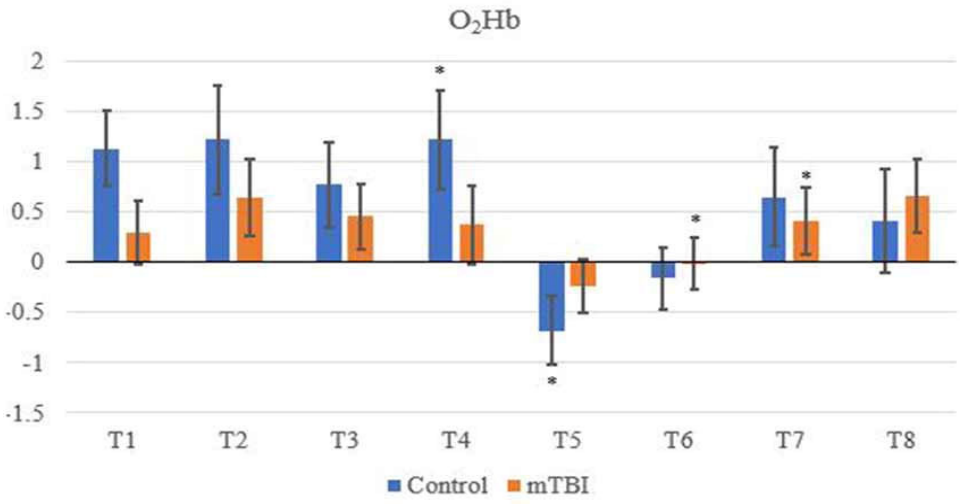

Figure: Mean O_2Hb NVC relative change from rest for all eight channels (represented by T-T8) for mTBI and control participants. Relative change refers to the occurred differential from baseline for the measured neurometabolic parameter (* denotes significant difference between the mTBI and control groups for the respective channel, $p < 0.01$).

Conclusion: This was the first study to examine cerebral hemodynamic changes in retired rugby players in response to a NVC test, and we found reduced cerebral hemodynamic responses in participants with a history of mTBI compared to controls. These results suggest altered cerebral metabolic demands in participants with a history of multiple head injuries. Further research is needed to ascertain an understanding of the changes in hemodynamics from playing into retirement.

Match and Training Injuries in Women's Rugby Union: a systematic review of unpublished studies

King, D., Hume, P., Cummins, C., Pearce, A., Clark, T., Foskett, A. & Barnes, M. (2019)

Objective: The aim of this systematic review was to describe the injury epidemiology for women's rugby-15s and rugby-7s match and training environments.

Methods: Systematic searches of PubMed, SPORTDiscus, Web of Science Core Collection, Scopus, CINAHL(EBSCO) and ScienceDirect databases using keywords.

Results: Ten articles addressing the incidence of injury in women's rugby union players were retrieved and included. The pooled incidence of injuries in women's rugby-15s was 19.6 (95% CI 17.7–21.7) per 1000 match-hours (h). The tackle was the most commonly reported injury cause with the ball carrier recording more injuries at the collegiate [5.5 (95% CI 4.5–6.8) vs. 3.5 (95% CI 2.7–4.6) per 1000 player-game-h; $\chi 2$ (1) = 6.7; p = 0.0095], and Women's Rugby World Cup (WRWC) [2006: 14.5 (95% CI 8.9–23.7) vs. 10.9 (95% CI 6.2–19.2) per 1000 match-h; $\chi 2$ (1) = 0.6; p = 0.4497; 2010: 11.8 (95% CI 6.9–20.4) vs. 1.8 (95% CI 0.5–7.3) per 1000 match-h; $\chi 2$ (1) = 8.1; p = 0.0045] levels of participation. Concussions and sprains/strains were the most commonly reported injuries at the collegiate level of participation.

Key Points:
►► The pooled incidence of match injuries was higher in women's rugby-7s than in women's rugby-15s (62.5 per 1000 match-h vs. 19.6 per 1000 match-h).
►► Pooled match injury rates (19.6 per 1000 match-h) were higher than pooled training injuries (1.5 per 1000 training-h) for women's rugby-15s.

Discussion: Women's rugby-7s had a higher un-pooled injury incidence than women's rugby-15s players based on rugby specific surveys and hospitalisation data. The incidence of injury in women's rugby-15s and rugby-7s was lower than men's professional rugby-15s and rugby-7s competitions but similar to male youth rugby-15s players. Differences in reporting methodologies limited comparison of results.

Key Points:
►►All pooled injury incidences for women's rugby-15s and rugby-7s were less than for men's rugby-15s and rugby- 7s at a comparable participation level.
►►The tackle resulted in the most injuries at all levels of participation.
►►The head/face was the most commonly reported injury site.

Conclusion: Women's rugby-7s resulted in a higher injury incidence than women's rugby-15s. The head/face was the most commonly reported injury site. The tackle was the most common cause of injury in both rugby-7s and rugby-15s at all levels. Future studies are warranted on injuries in women's rugby-15s and rugby-7s.

Taylor Lee – PhD student, Purdue University

Research specialisation: Repetitive head acceleration events sustained in contact sports.

Research experience: Member of the Human Injury Research and Regenerative Technologies Lab and the Purdue Neurotrauma Group for the last 4 years as a graduate student. I have worked on projects aimed to characterize head impacts sustained in contact sports (primarily American football) and how they may lead to neurological changes that do not result in easily observable clinical symptoms. Specifically, I am interested in finding techniques and practices that can help reduce the number and/or severity of the head impacts sustained by contact sport athletes. I have experience with various head-mounted sensor systems and am competent in Matlab and Stata.

Research overview: After conducting various studies on American football players, I wanted to compare the collected data to that of rugby players since the sports have enough similarities and differences that allow for an interesting comparison. I will be studying secondary school rugby athletes using instrumented mouthguards to quantify the acceleration of the head during collisions sustained in games and practices. I will also be performing cognitive testing and brain scans with MRI to determine if there are changes that can be detected with these evaluations that may be due to the collisions. The goal is to compare to previous literature from other contact sports and determine if these athletes are also at risk for neurological changes seen in those athletes.

Research publications:

Lee T, Lycke RJ, Lee PJ, Cudal CM, Torolski KJ, Bucherl SE, Leiva Molano N, Auerbach PS, Talavage TM and Nauman EA. Distribution of Head Acceleration Events Varies by Position and Play Type in North American Football. Clinical Journal of Sports Medicine (Accepted 19 Jun 2019).

Bari S, Svaldi DO, Jang I, Shenk TE, Poole VN, Lee T, Dydak U, Rispoli JV, Nauman EA, Talavage TM. Dependence on subconcussive impacts of brain metabolism in collision sport athletes: an MR spectroscopic study. Brain imaging and behavior. 2019 Jun 15;13(3):735-49.

Jang I, Chun IY, Brosch JR, Bari S, Zou Y, Cummiskey BR, Lee TA, Lycke RJ, Poole VN, Shenk TE, Svaldi DO. Every hit matters: White matter diffusivity changes in high school football athletes are correlated with repetitive head acceleration event exposure. NeuroImage: Clinical. 2019 Jul 16:101930.

Selected abstracts and technical reports:

- Yang H, Yao J, Wang JH, Liang Z, Kish B, Tu J, **Lee T**, Vike N, Kashyap P, Bari S, Zou Y, Jang I, Vincent J, Mao X, Tamer G, Nauman E, Talavage T and Tong Y. *Characterizing Near-Infrared Spectroscopy Signal Under Hypercapnia*. BMES 2019 Annual meeting, October 16-19, 2019.
- Zou Y, **Lee T**, Lycke RJ, Jang I, Vike NL, Nauman EA, Talavage TM, Rispoli JV. *High -G Head Collisions are Associated with Short-Term White Matter Microstructural Deficits in High School Football Athletes.* Neurotrauma 2018. Toronto, Canada, August 11-16, 2018. Published by Journal of Neurotrauma, Vol. 35, No. 16, pp. A23-23.

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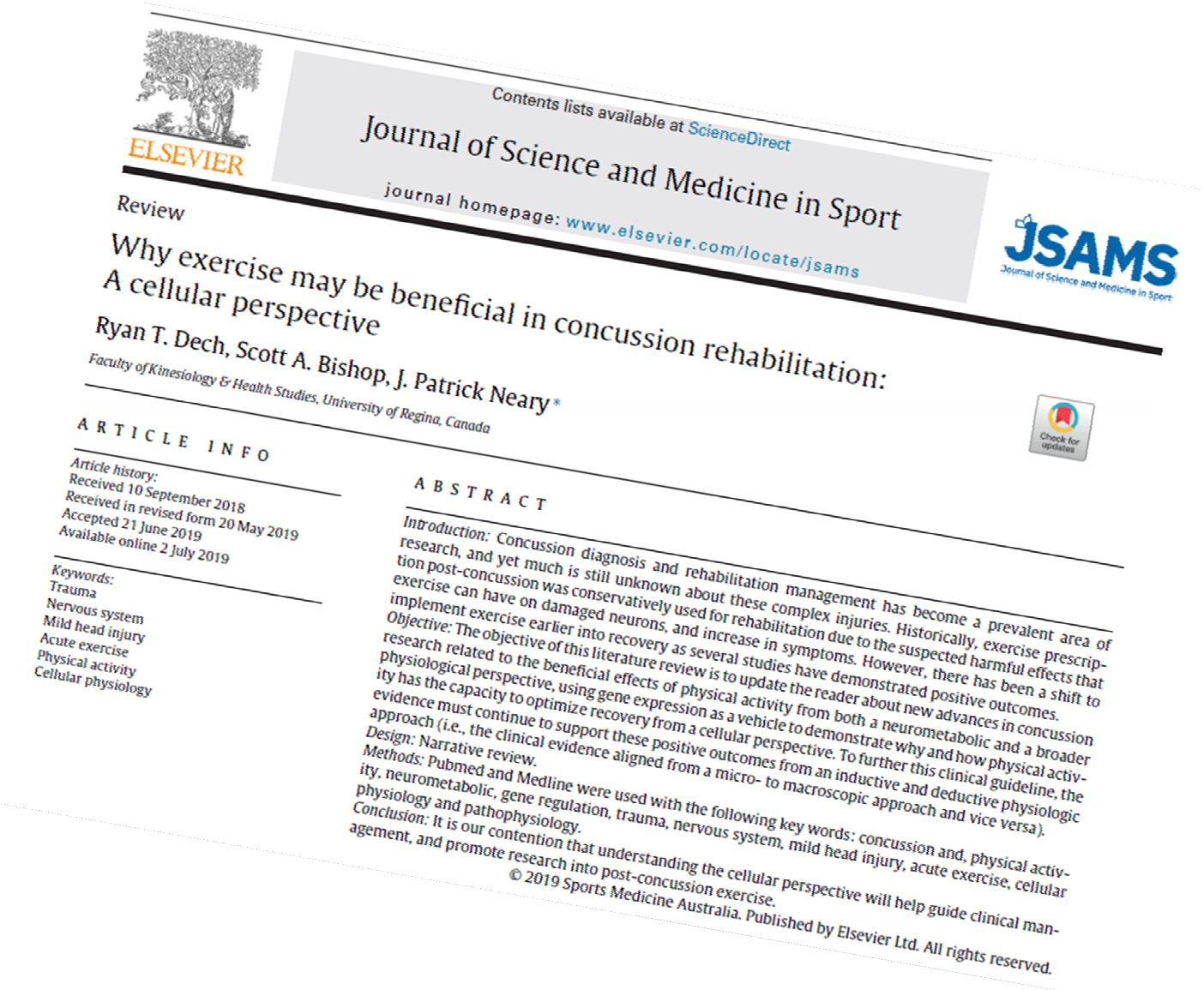
Expand your thinking… what do you think of this paper?



Contents lists available at ScienceDirect

Journal of Science and Medicine in Sport

journal homepage: www.elsevier.com/locate/jsams

Review

Why exercise may be beneficial in concussion rehabilitation: A cellular perspective

Ryan T. Dech, Scott A. Bishop, J. Patrick Neary *

Faculty of Kinesiology & Health Studies, University of Regina, Canada

ARTICLE INFO

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Keywords:
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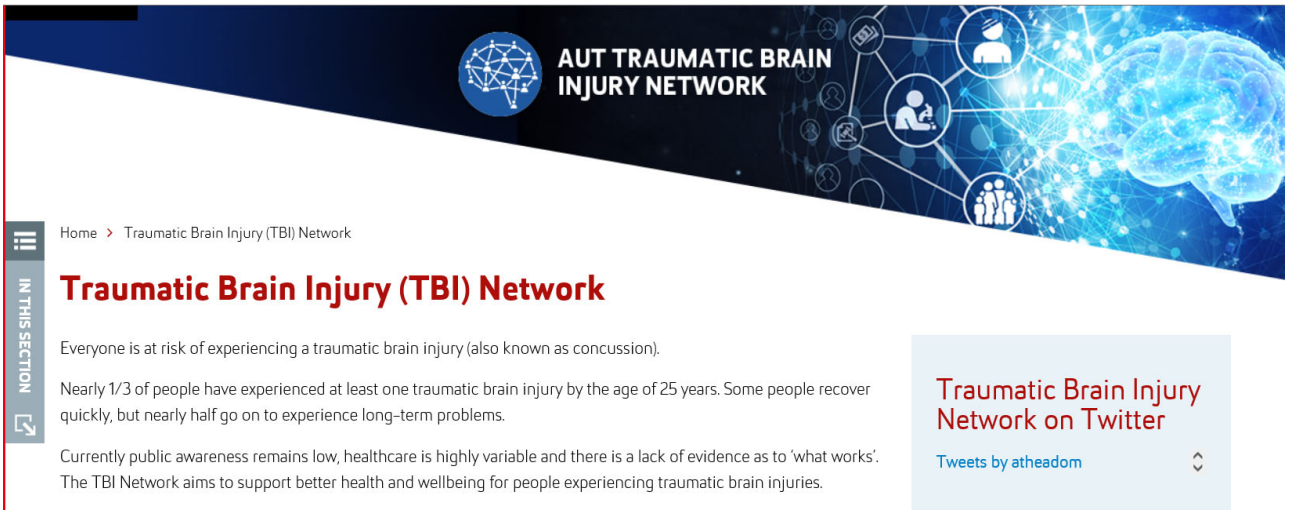
Mild head injury
Acute exercise
Physical activity
Cellular physiology

ABSTRACT

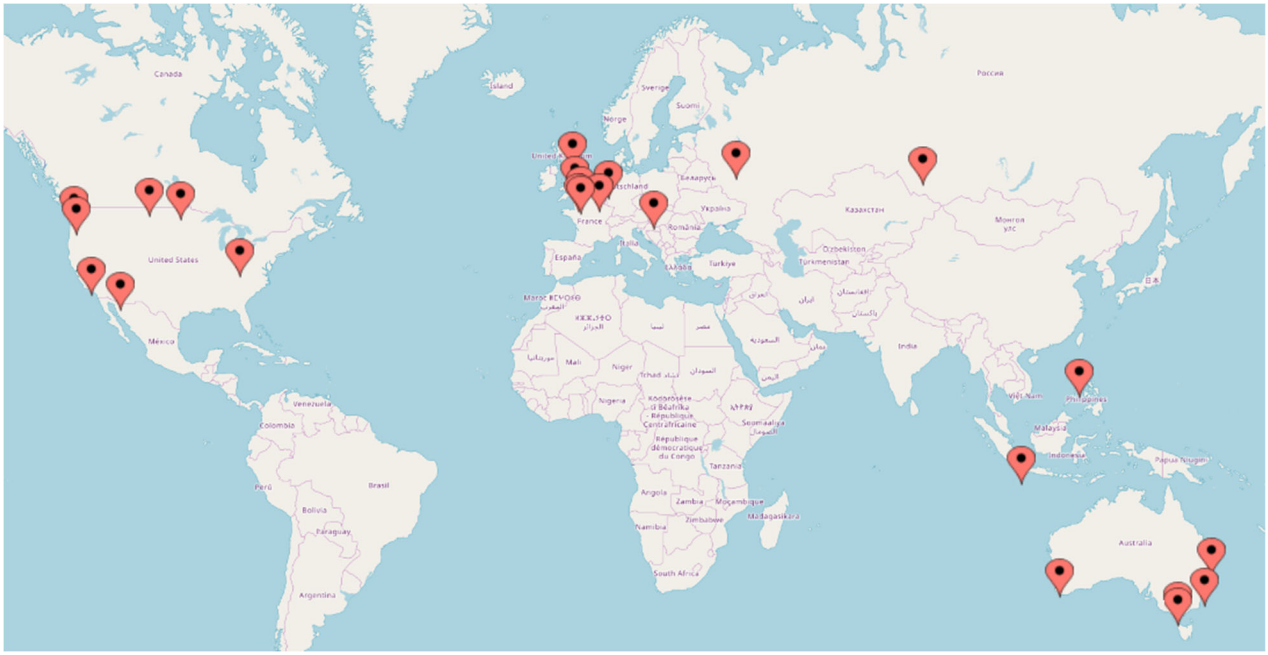
Introduction: Concussion diagnosis and rehabilitation management has become a prevalent area of research, and yet much is still unknown about these complex injuries. Historically, exercise prescription post-concussion was conservatively used for rehabilitation due to the suspected harmful effects that exercise can have on damaged neurons, and increase in symptoms. However, there has been a shift to implement exercise earlier into recovery as several studies have demonstrated positive outcomes.
Objective: The objective of this literature review is to update the reader about new advances in concussion research related to the beneficial effects of physical activity from both a neurometabolic and a broader physiological perspective, using gene expression as a vehicle to demonstrate why and how physical activity has the capacity to optimize recovery from a cellular perspective. To further this clinical guideline, the evidence must continue to support these positive outcomes from an inductive and deductive physiologic approach (i.e., the clinical evidence aligned from a micro- to macroscopic approach and vice versa).
Design: Narrative review.
Methods: Pubmed and Medline were used with the following key words: concussion and, physical activity, neurometabolic, gene regulation, trauma, nervous system, mild head injury, acute exercise, cellular physiology and pathophysiology.
Conclusion: It is our contention that understanding the cellular perspective will help guide clinical management, and promote research into post-concussion exercise.

We look forward to receiving your paper summaries for inclusion in the next issue of the RCRG e-Mag.

AUT Traumatic Brain Injury Network



Director Professor Alice Theadom launched the TBI Network online on 21st May 2019 with Professor Max Abbott and Professor Patria Hume. Since then, the network has attracted over 250 members, with new members joining every week. The membership includes 70 community (public members), 113 clinicians (including trauma specialists, GPs, occupational therapists, physiotherapists, psychologists, audiologists, sports physiologists, addition and mental health service personnel) and 56 academics. There is a strong and growing international presence with academic members based across the US, Canada, UK, Australia, Europe and Brazil. The TBI Network has strong international collaborations and links with the three largest TBI funded programmes including TRACK-TBI and InTBIR in the US, CENTER-TBI and UPFRONT in Europe and TBI VISION in Australia.



For more information see **https://www.aut.ac.nz/traumatic-brain-injury-tbi-network**

In this section:

In the media

- Kiwi research shows women take longer to recover from concussions than men (Article quoting Alice Theadom, Newshub, 9 October 2019)
- The Check Up (TVNZ On Demand) (S1 E6 features Alice Theadom, originally aired on Monday 13 August 2019)
- Recovery from concussion in children (Nicola Starkey interviewed on RNZ Nine To Noon, 4 July 2019)
- Launch of the TBI Network (Alice Theadom interviewed on RNZ Nine To Noon, 21 May 2019)
- "Worse than hell" – life behind bars with a traumatic brain injury (Alice Theadom interviewed on NewsHub, 6 May 2018)
- Mild concussions can impact daily function up to four years on, new research shows (Article featuring Alice Theadom, Stuff.co.nz, 3 February 2018)
- Traumatic brain injury and dementia (Alice Theadom interviewed on Radio New Zealand, 1 February 2018)

Research summaries

These participant research summaries cover the key findings from some of our recent projects.

- Download Equestrian Athletes' Concussion Awareness research summary [PDF, 82.5 KB]
- Download Parents' Concussion Awareness research summary [PDF, 200.4 KB]
- Download Students' Concussion Awareness research summary [PDF, 271.1 KB]
- Download BIONIC infographics (Brain Injury Outcomes New Zealand in the Community) [PDF, 372.0 KB]

Latest research findings

These summarise key messages from research conducted from across the globe.

- Download 'Case-mix, care pathways, and outcomes in patients with TBI in CENTER-TBI: a European prospective, multicentre, longitudinal, cohort study' [PDF, 208.1 KB]
- Download 'Evolution of Evidence and Guideline Recommendations for Medical Management of Severe Traumatic Brain Injury' [PDF, 179.3 KB]

Members of the Global Rugby health Research Group are also members of the **AUT TBI Network**. See the example brain health related publications at **https://sprinz.aut.ac.nz/areas-of-expertise/rugby-codes/brain-health-publications**

Brain health publications

We are part of the Traumatic Brain Injury Network and are researching ways that are contributing to brain health. Please find below the publications that outline individual projects further:

- Hume 2019 NZJSM V45-2 pg 78-82 Selected Abstracts
  Concussion carries with it a lot of stigma in sport and is colloquially referred to as a head-knock or bell-ringer, undermining the seriousness of the injury. While all concussions are mild traumatic brain injuries, not all mild traumatic brain injuries are concussions although these terms are used interchangeably. Therefore, experts have proposed that sport-originated brain injury (SOBI) is used to describe sports-related concussions.

Incidence

- King 2018 Inj rugby 1 to 5 concussion NZJSM 45-1 pg 22-33
  During an amateur rugby season, an average of 4 injuries per match were recorded, of which one was a concussion. Less than 20% of these were witnessed and only identified after the match with the SCAT and KD tools.
  N = 71 M
  Senior RU
- King 2018 Concussion SnrRL NZ SportsMedRehabJ
  Amateur representive players sustain more than twice as many concussions as premier domestic players. Concussions to the ball-carrier are three times as likely as concussions to the tackler. Most injuries occur in the last quarter of the match.
  Senior RL
- King etal 2018 Sports injuries NZ ACC 5 sports 2012T16 BJSM
  Rugby Union is responsible for the most serious and severe concussions out of the most popular NZ team sports; rugby, football, netball and cricket. Claims by females however, were three times as high in football than rugby and twice as high as in cricket. The number of claims for head injuries is increasing over time.
- King 2016 Semi-Prof rugby league concussion pooled analysis SportsMed
  A review of 25 studies that included male, female, amateur, professional and junior rugby league players revealed that amateur players have the highest incidence of match time concussions (1 every 40 games) and professional players have the highest incidence of training time concussions.
- Lopez 2017 Injury rates in rugby 7's
  N = 960 M & 888 F
  RISE report
  This is one of the first studies to report time loss due to injury in rugby. A total of 244 injuries were sustained over eight days of sub-elite Rugby 7's tournaments resulting in a loss of 60 hours of play per 1000 hours. Backs sustained more injuries than forwards, with most of these injuries sustained by men. The concussion rate was 6%. This study provides valuable information in the guidance of injury prevention protocols in US rugby.

Epidemiology/Injury risk

- King 2019 ACC TBI JNS

  Moderate concussions are most likely to be caused by falls (41%) and serious or severe concussions by car accidents (36% and 56%, respectively). Despite these injuries costing ACC $300 million per year, little is known about the long term effects.

- King 2017 RESQT NZJSM 43-2 p57-63

  Players with high stress scores were more likely to get injured over the course of a rugby season.
  N = 30
  Senior
  Amateur RL

- Hume 2017

  366 retired elite and community rugby players and a non-contact sport group were assessed for cognitive function. Compared to the non-contact sport group, the elite players performed worse in attention, speed and switching tasks. Community players also performed better in attention. A history of concussions also significantly reduced scores. These results indicate long-term effects on mental ability and have implications for concussion management at the time of injury.
  N = 366 M
  Age = 43±8

Rehabilitation

- McGeown 2018 Implementing a structured exercise program for persistent concussion symptoms a pilot study on the effects on salivary brain derived neurotrophic

  Concussion symptoms can persist for a substantial time after the injury is sustained. This study found that compared to normal values, people who had suffered a concussion had significantly lower levels of BDNF, a marker of brain function. A four week aerobic and exercise programme significantly improved persistent concussion symptoms although it did not increase BDNF.

Diagnosis/Tools

- King 2018 Brain Gauge IPPR-18-4361

  The Brain Gauge is a 20 minute test involving a battery of tactile tasks that assess reaction time, amplitude discrimination, temporal order judgment and duration discrimination. A case study of a female patient revealed that, compared to normal scores, the Brain Gauge was sensitive; tracking concussion symptoms and recovery.
  A patient with a history of sports-related concussions underwent a rigorous neurological assessment using the Neary Protocol. This revealed that the patient's symptoms were a result of underlying balance and dizziness conditions. Patients with a history of concussions should undergo proper testing to ensure the most appropriate treatment and prevent long-term issues.

Mechanisms

- Lewis 2017

  Brain injury affects the ability to stimulate movement. Whether this persists long-term is unclear. The brains of elite and community ex-rugby players were artificially stimulated to produce movement. Compared to players from non-contact sports, a bigger signal was required to produce a reaction in the elite players, indicating some long-term damage. Interestingly, there was no difference between the elite and community players despite them having experienced a similar number of concussions.
  N = 73