

# Rugby Codes Research Group

## e-Magazine

Volume 9 (Nov) 2021

Hume, P.A. and King, D. Editors.

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RCRG website:

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



AUT SPORTS PERFORMANCE  
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AUT MILLENNIUM

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## E-MAGAZINE EDITORS WELCOME

Welcome to volume 9 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.

The RCRG 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). 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.

### RCRG aims

- Bring together expertise that integrates areas of sport research (injury prevention, strength & conditioning, sport technology, coaching, psychology, physiology, performance analysis, leadership, management, epidemiology, pathology, engineering).
- Offer leading edge design and development solutions to rugby organisations, teams, and players around the world.

For more information including membership forms, see <https://sprinz.aut.ac.nz/areas-of-expertise/rugby-codes>

The RCRG aims to share information for teaching and research. As examples, in this edition of the RCRG eMagazine you will see the slides provided by Dr Chris Nowinski <[nowinski@concussionfoundation.org](mailto:nowinski@concussionfoundation.org)> and Dr Robert Cantu on the 1,000 Reasons for Hope report on how the first donors of their brains at the VA-BU-CLF Brain Bank are mapping the future of brain trauma research. Prof Alice Theadom has provided slides on the Traumatic Brain Injury Network and the Brain Injury Screening Tool.

These slides are available to RCRG members from the Global Rugby Health Research Group Team site. If you would like access to this site to gain these slides, or to share your work, please contact [patria.hume@aut.ac.nz](mailto:patria.hume@aut.ac.nz).

In this eMagazine edition you will also see new members' profiles, and summaries of research groups' work. We profile the group from Swansea University who joined the RCRG in October 2021. Dr Victor Lopez Jr from the USA provides an update on projects and presentations since his last report in 2019. Head impacts are becoming a very topical issue so Dr Doug King has summarized the research conducted by his team in expanding the knowledge and awareness of head impact biomechanics.

**RCRG e-Magazine contributions can be sent to:** [Patria.Hume@aut.ac.nz](mailto:Patria.Hume@aut.ac.nz)

# THE GLOBAL RUGBY HEALTH RESEARCH GROUP

The GRHRG aims to help prevent, identify and treat injuries that occur through participation in the rugby codes through connecting researchers, clinicians, patients / whanau, funders, policy makers and media.

See <https://sprinz.aut.ac.nz/areas-of-expertise/rugby-codes/global-rugby-health-research-programme>

## The Global Rugby Health Research Programme (GRHRP) – Members

Principal Investigators and Collaborators and focus of studies in each country include:

- New Zealand 2013.** Inaugural World Rugby/New Zealand Rugby/AUT NZ RugbyHealth Project (completed) - GHQ, CNSVS, balance and TMS studies. Extension projects GRHR collaborations, impact biomechanics. 2017-18.
  - Prof Patria Hume**, Assoc Prof Alice Theadom, Assoc Prof Gwyn Lewis, Prof Denise Taylor, Dr Scott Brown, Liz Binns, Matthew Brughelli, Dr Doug King, Joshua McGeown (AUT), Dr Ken Quarrie (NZR & AUT), Assoc Prof Stephen Marshall (Chapel Hill), Dr Rosamund Hill (Auckland Hospital), Stephen Kara & Mark Fulcher (Axis Sports Medicine).
- UK 2016.** GHQ, CNSVS, KD test, bloods, balance, tensiomyography, cranial NIRS, DXA, physiological biomarkers (ECG) to determine heart rate variability changes.
  - Dr Karen Hind**, Ian Entwistle, Mr Costas Tsakirides, Dr Michelle Swainson, Dr Antonis Stavropoulos-Kalinoglou, Anick Sharma, Prof Clive Begg, Dr Peter Francis (Leeds Beckett University), Prof Richard Aspden & Dr Jenny Gregory (Unj of Aberdeen), Dr Madeleine Davies & Prof Nigel Arden (Oxford), Chris Nowinsky & Ann McKee (Harvard).
- Canada 2017.** GHQ, CNSVS, physiological biomarkers (ECG) to determine heart rate variability changes; continuous blood pressure monitoring for blood pressure variability, changes and cranial NIRS).
  - Prof Patrick Neary** (University of Regina) and Drs Steve Martin, Kathy Gaul, Lynne Stuart-Hill (University of Victoria).
- Australia 2017.** GHQ, CNSVS, KD test, bloods, DXA and TC MRI, impact biomechanics.
  - Dr Clare Fraser** (Save Sight Institute, University of Sydney), Dr Alan Pearce (La Trobe University), Cloe Cummins (University of New England), Jarrod Meerkin (MeasureUp), Dr Gary Slater (Unj Sunshine Coast), Assoc Prof Jacqueline Alderson (University of Western Australia), Prof Melinda Fitzgerald (Curtin University).
- USA 2018.** GHQ, CNSVS.
  - Max McKee-Proctor**, Dr. Lyle Micheli, John Decker, Dai Sugimoto, William Meehan (Boston Children's Hospital), Victor Lopez, Robert Cantu, Chris Nowinski
- South Africa 2018.** GHQ.
  - Dr James Brown**, Dr Julian Pillay & Emily (Stellenbosch University).
- Wales 2021.** Biomechanics and physiology.
  - Prof Liam Kilduff**, Neil Bezodis, Dr Mark Waldron (Swansea University).



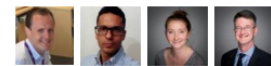
Lead PIs: Patria, Doug, Karen



Alice, Gwyn, Ken, Denise, Scott, Rosamund, Matt, Liz



Ian, Costas, Michelle, Antonis, Richard, Jenny Clive



Peter, Anick, Madeleine, Nigel



Patrick, Steve, Kathy, Lynne



James, Julian, Emily



Clare, Alan, Jarrod, Gary, Melinda, Jacqueline, Cloe



Max, Lyle, John, Scott, Steve, Robert, Victor



Liam, Neil, Mark

## Global Rugby Health Research Programme and studies – health effects on retired sports players

	Epi	GHQ	CNSVS	TMS	Balance	DXA	Cranial NIRS	Tensiomyography	Physiological biomarkers (ECG, BP, HR)	King Devick	TC MRI	Blood biochemistry	OAQ	Impact biomech	Wearables
<b>New Zealand</b> Prof Patria Hume Dr Doug King	★	★	★	★	★		★		★	★				★	★
<b>United Kingdom</b> Dr Karen Hind		★	★	★	★	★	★	★	★	★		★	★		
<b>Australia</b> Dr Clare Fraser		★	★	★	★	★				★	★	★		★	
<b>Canada</b> Prof Patrick Neary		★	★				★		★						
<b>USA</b> Dr Max McKee-Proctor	★	★	★							★			★		
<b>South Africa</b> Dr James Brown		★	★												
<b>Wales</b> Prof Liam Kilduff						★			★					★	★



Data collection in progress



Data collection completed

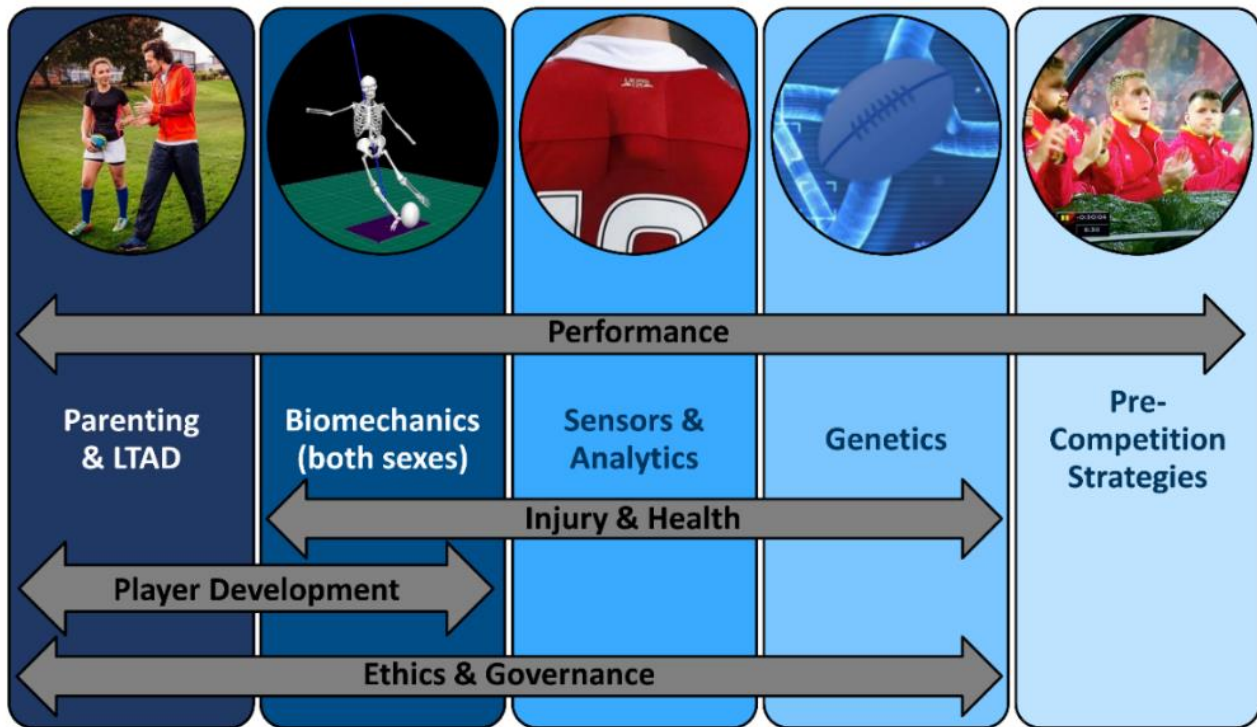


Journal publication completed



## Swansea University: Staff Active in Rugby Science Research

**Research specialisations:** The rugby research conducted within the Applied Sports, Technology, Exercise and Medicine (A-STEM) Research Centre at Swansea University encompasses a wide range of expertise, techniques, and research methods, and is primarily applied across four cross-cutting themes in Rugby (Figure 1).



**Figure 1.** Schematic of the themes and applications of rugby research across A-STEM.

**Research overview:** The groups work closely with a range of domestic, national and international stakeholders including professional teams, international unions and technology firms. The research is almost always end-user driven, often interdisciplinary in nature, and has impacted areas such as matchday preparation and routines, psychosocial development and social support, and player development pathways.

**Experience:** The A-STEM Research Centre comprises 3 research groups, each of which contain considerable experience in different rugby-related applications. Rugby active staff within the Elite and Professional Sport (EPS) Group (Prof Kilduff, Prof Knight, Dr Bezodis, Dr Brown, Dr Heffernan, Dr Waldron) primarily focus on performance applications, staff within the Exercise, Medicine and Health (EMH) Group (Prof Mackintosh, Prof McNarry, Prof Stratton, Dr Williams) primarily focus on injury, health and player development, whilst staff within the Sport Ethics, Integrity and Governance (SEIG) Group (Dr Bloodworth, Dr Devine) primarily focus on ethics, anti-doping and philosophy.

Elite and Professional Sport (EPS) Research Group:

- Dr Neil Bezodis – Biomechanics, kicking, speed and acceleration, technique, injury
- Dr Rowan Brown – Data analytics, player/team metrics, machine learning applications
- Dr Shane Heffernan – Molecular genetics, elite rugby athlete physiology, muscle physiology, softtissue injury, concussion
- Dr Mark Waldron – Micro-technology and player monitoring, testing and training, applied physiology
- Prof. Liam Kilduff – Competition demands, optimising the training process, recovery modalities, competition day preparation
- Prof. Camilla Knight – Parenting, social support, psychosocial development



**Exercise, Medicine and Health (EMH) Research Group:**

- Prof. Kelly Mackintosh – Maturation, skill development, visualisation
- Dr Elisabeth Williams – Biomechanics, head impact monitoring and neck strength, biomedicalengineering, women's rugby
- Prof. Melitta McNarry – LTAD, maturation, training loads, performance

**Sport Ethics, Integrity and Governance (SEIG) Research Group:**

- Dr Andrew Bloodworth – Anti-doping
- Dr John William Devine – Philosophy, ethics, leadership, enhancement

**Post-Doctoral Research Assistants:**

- Dr Dan Cunningham – Competition demands
- Dr Natalie Brown – Women's rugby, player and coach education

**Postgraduate supervision:** Members of A-STEM have supervised nine rugby-related PhDs and MScs by Research to completion, and there are currently six active PhD students working on rugby-specific projects.

- Ms Freja Petrie (current)
- Mr David Powell (current)
- Ms Georgia Scott, Ospreys Rugby (current)
- Mr James Wild, Harlequins FC (current)
- Mr Luke Woodhouse, RFU Women (current)
- Mr Stuart Yule, Scottish Rugby Union (current)
- Dr Luke Cox (completed 2021)
- Dr Emily Owen, Ospreys in the Community (completed 2021)
- Dr Olivier Rouquette, part RFU (completed 2020)
- Dr Chris Pocock (completed 2019)
- Dr Alexandra Attack, part RFU (completed 2016)
- Dr Nicola Furlan, Rugby Australia Sevens (completed 2016)
- Dr Michael Johnston, Ulster Rugby (completed 2015)
- Dr Rhys Jones, Scarlets Rugby (completed 2015)
- Dr Huw Bevan, Ospreys Rugby (completed 2012)

**Applied Sports, Technology, Exercise, and Medicine (A-STEM) Research Centre (led by Professor Liam Kilduff)**

<https://www.swansea.ac.uk/sports-science/astem/>

**Elite and Professional Sport (EPS) Research Group, Swansea University (led by Dr Neil Bezodis)**

<https://www.swansea.ac.uk/sports-science/astem/eps/>

**Exercise, Medicine and Health Research Group, Swansea University (led by Prof Kelly Mackintosh)**

<https://www.swansea.ac.uk/sports-science/astem/emh/>

**Sport Ethics, Integrity and Governance Research Group, Swansea University (led by Dr Andrew Bloodworth)**

<https://www.swansea.ac.uk/sports-science/astem/seig/>

**Welsh Institute of Performance Science**

(<https://www.swansea.ac.uk/sports-science/astem/wips/>)

**Faculty of Science & Engineering  
Bay Campus  
Swansea University  
Wales**

**Research publications:** To date, staff across the three Research Groups within A-STEM have published > 115 rugby-related articles. A full list of these is available [here](#).

These are selected recent publications from the group (*For full reverse chronological list on Web of Science please click [here](#).*)

Attack, A., Trewartha, G., & **Bezodis, N.E.** (2019). A joint kinetic analysis of rugby place kicking technique to understand why kickers achieve different performance outcomes. *Journal of Biomechanics*, 87, 114-119.

<https://doi.org/10.1016/j.jbiomech.2019.02.020>

Bennett, M., **Bezodis, N. E.**, Shearer, D. A., & **Kilduff, L. P.** (2021). Predicting performance at the group-phase and knockout-phase of the 2015 Rugby World Cup. *European Journal of Sports Science*, 21(3), 312-320.

<https://doi.org/10.1080/17461391.2020.1743764>

Crewther, B. T., Potts, N., **Kilduff, L. P.**, Drawer, S., & Cook, C. J. (2020). Performance indicators during international rugby union matches are influenced by a combination of physiological and contextual variables. *Journal of Science and Medicine in Sport*, 23(4), 396-402. <https://doi.org/10.1016/j.jsams.2019.10.011>

**Cunningham, D. J.**, Shearer, D. A., Drawer, S., Pollard, B., Eager, R., Taylor, N., Cook, C. J., & **Kilduff, L. P.** (2016). Movement demands of elite under-20s and senior international Rugby Union players. *PLoS One*, 11(11), e0164990. <https://doi.org/10.1371/journal.pone.0164990>

**Devine, J. W.** (2021). O captain! My captain!: Leadership, virtue, and sport. *Journal of the Philosophy of Sport*, 48(1), 45-62. <https://doi.org/10.1080/00948705.2020.1848435>

Gray, A. J., Shorter, K., Cummins, C., Murphy, A., & **Waldron, M.** (2018). Modelling movement energetics using Global Positioning System (GPS) devices in contact team sports: limitations and solutions. *Sports Medicine*, 48, 1357-1368. <https://doi.org/10.1007/s40279-018-0899-z>

Greybe, D. G., Jones, C. M., **Brown, M. R.**, & **Williams, E. M. P.** (2020). Comparison of head impact measurements via an instrumented mouthguard and an anthropometric testing device.

*Sports Engineering*, 23, 12. <https://doi.org/10.1007/s12283-020-00324-z>

Hall, E. C. R., Almeida, S. S., **Heffernan, S. M.**, Lockey, S. J., Herbert, A. J., Callus, P., Day, S. H., Pedlar,

C. R., Kipps, C., Collins, M., Pitsiladis, Y. P., Bennett, M. A., **Kilduff, L. P.**, Stebbings, G. K., Erskine, R. M., & Williams, A. G. (2021). Genetic polymorphisms related to VO2max adaptation are associated with elite rugby union status and

- competitive marathon performance. *International Journal of Sports Physiology and Performance*, in press.  
<https://doi.org/10.1123/ijsp.2020-0856>
- Heffernan, S. M., Kilduff, L. P.,** Erskine, R. M., Day, S. H., Stebbings, G. K., Cook, C. J., Raleigh, S. M., Bennett, M. A., Wang, G., Collins, M., Pitsiladis, Y. P., & Williams, A. G. (2017). COL5A1 gene variants previously associated with reduced soft tissue injury risk are associated with elite athlete status in rugby. *BMC Genomics*, 18(8), 29-37. <https://doi.org/10.1186/s12864-017-4187-3>
- Heffernan, S. M.,** Stebbings, G. K., **Kilduff, L. P.,** Erskine, R. M., Day, S. H., Morse, C. I., McPhee, J. S., Cook, C. J., Vance, B., Ribbans, W. J., Raleigh, S. M., Roberts, C., Bennett, M. A., Wang, G., Collins, M., Pitsiladis, Y. P., & Williams, A. G. (2017). Fat mass and obesity associated (FTO) gene influences skeletal muscle phenotypes in non-resistance trained males and elite rugby playing position. *BMC genetics*, 18(1), 1-9. <https://doi.org/10.1186/s12863-017-0470-1>
- Lazarczuk, S. L., **Love, T.**, Cross, M. J., Stokes, K. A., Williams, S., Taylor, A. E., Fuller, C. W., Brooks, J. H. M. Kemp, S. P. T., & **Bezodis, N. E.** (2020). The epidemiology of kicking injuries in professional Rugby Union: a 15-season prospective study. *Scandinavian Journal of Medicine of Medicine and Science in Sports*, 30(9), 1739-1747.  
<https://doi.org/10.1111/sms.13737>
- Pocock, C., **Bezodis, N. E.**, Davids, K., & North, J. S. (2021). Effects of manipulating specific individual constraints on performance outcomes, emotions, and movement phase durations in Rugby Union place kicking. *Human Movement Science*, 79, 102848. <https://doi.org/10.1016/j.humov.2021.102848>
- Rouquette, O. Y., **Knight, C. J.**, Lovett, V. E., Barrell, D., & Heuzé, J.-P. (2021) The positive association between perceived parental responsiveness and self-esteem, anxiety, and thriving among youth rugby players: A multigroup analysis, *Journal of Sports Sciences*, 39(13), 1537-1547. <https://doi.org/10.1080/02640414.2021.1883311>
- Sheppy, E., Hills, S. P., Russell, M., Chambers, R., **Cunningham, D. J.**, Shearer, D., **Heffernan, S.**, **Waldron, M.**, **McNarry, M.**, & **Kilduff, L. P.** (2020). Assessing the whole-match and worst- case scenario locomotor demands of international women's rugby union match-play. *Journal of Science and Medicine in Sport*, 23(6), 609-614.  
<https://doi.org/10.1016/j.jsams.2019.12.016>
- Waldron, M.**, Jones, C., Melotti, L., **Brown, R.**, & **Kilduff, L. P.** (2021). Collision monitoring in elite male rugby union using a new instrumented mouth-guard. *The Journal of Sports & Exercise Sciences*, 5(3), 179-187.  
<https://doi.org/10.36905/jses.2021.03.03>
- Williams, E. M. P.**, Petrie, F. J., Pennington, T. N., Powell, D. R. L., Arora, H., **Mackintosh, K. A.**, & Greybe, D. G. (2021). Sex differences in neck strength and head impact kinematics in university rugby union players. *European Journal of Sports Science*, in press, doi pending.
- Woodhouse, L., Tallent, J., Patterson, S., & **Waldron, M.** (2021). Elite international female rugby union physical match demands: A five-year longitudinal analysis by position and opposition quality. *Journal of Science & Medicine in Sports*, in press. <https://doi.org/10.1016/j.jsams.2021.03.018>
- Wright, F., Docherty, P. D., **Williams, E. M. P.**, Greybe, D. G., Hari Arora, H., & Kabaliuk, N. (2021). An in-silico study of the effect of non-linear skin dynamics on skin-mounted accelerometer inference of skull motion. *Biomedical Signal Processing and Control*, 70, 102986. <https://doi.org/10.1016/j.bspc.2021.102986>

## NEW MEMBER'S PROFILES

### Dr Neil Bezodis PhD

**Research specialisation:** Sports Biomechanics and Performance

**Experience:** Dr Neil Bezodis is an Associate Professor in Biomechanics & Technology at Swansea University, UK. He previously worked at St Mary's University, Twickenham, where he led a project working with the RFU to provide biomechanical support and research for their Development Pathway and Elite kickers. Since moving to Swansea, he has continued his kicking work with Scarlets Rugby and broadened the focus to injury as well as performance, whilst also working with colleagues on wider performance science and data analytics research in Rugby Union. He is currently the sports science PI for a Welsh Government funded interdisciplinary project which is developing novel smart technologies for use by elite and professional athletes. He is the lead of the Elite and Professional Sport (EPS) Research Group (<https://www.swansea.ac.uk/sports-science/astem/eps/>) within the Applied Sports, Technology, Exercise and Medicine (A-STEM) Research Centre at Swansea University, the Biomechanics Lead for the Welsh Institute of Performance Science (WIPS; <https://www.swansea.ac.uk/sports-science/astem/wips/>), and the current Vice-President (Awards) of the International Society of Biomechanics in Sports (ISBS; <https://isbs.org/>).



**Research overview:** Dr Bezodis has worked with domestic and international rugby organisations for over 10 years. The research undertaken as part of these collaborations primarily focusses on the biomechanics of kicking and training for speed, and has resulted in numerous publications, PhD completions and funding.

**Postgraduate supervision:** 6 Masters by research and 5 PhD research students to completion. Currently supervising 1 Masters by research, 4 PhD (all funded by and/or embedded in elite and professional sports organisations) and 1 EngD student.

**Research publications:** >40 peer reviewed publications (<https://www.webofscience.com/wos/woscc/summary/d039ecb9-72be-405b-befc-28827625270b-0419ebee/relevance/1>) and 2 invited book chapters. Editorial board member of *Sports Biomechanics*.

Example publications:

1. Bennett, M., **Bezodis, N. E.**, Shearer, D. A., & Kilduff, L. P. (2021). Predicting performance at the group-phase and knockout-phase of the 2015 Rugby World Cup. *European Journal of Sport Science*, 21(3), 312-320.
2. Pocock, C., **Bezodis, N. E.**, Davids, K., & North, J. S. (2021). Effects of manipulating specific individual constraints on performance outcomes, emotions, and movement phase durations in Rugby Union place kicking. *Human Movement Science*, 79, 102848.
3. Lazarczuk, S. L., Love, T., Cross, M. J., Stokes, K. A., Williams, S., Taylor, A. E., Fuller, C. W., Brooks, J. H. M. Kemp, S. P. T., & **Bezodis, N. E.** (2020). The epidemiology of kicking injuries in professional Rugby Union: a 15-season prospective study. *Scandinavian Journal of Medicine of Medicine and Science in Sports*, 30(9), 1739-1747.
4. Atack, A., Trewartha, G., & **Bezodis, N.E.** (2019). A joint kinetic analysis of rugby place kicking technique to understand why kickers achieve different performance outcomes. *Journal of Biomechanics*, 87, 114-119.
5. Wild, J.J., Bezodis, I.N., North, J.S., & **Bezodis, N.E.** (2018). Differences in step characteristics and linear kinematics between rugby players and sprinters during initial sprint acceleration. *European Journal of Sport Science*, 18(10), 1327-1337.



**Neil Bezodis (Ph.D.)**  
Associate Professor of Biomechanics & Technology

Lead of the Elite and Professional Sport (EPS)  
Research Group, Swansea University  
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Biomechanics Lead for the Welsh Institute of  
Performance Science  
(<https://www.swansea.ac.uk/sports-science/astem/wips/>)

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## Dr. Mark Waldron PhD, MSc, BSc

### Research specialisation: Applied Physiology and Performance

**Experience:** Dr. Mark Waldron is a Senior Lecturer in Sports and Exercise Sciences at Swansea University (UK) and a Senior Research Fellow at the University of the Sunshine Coast, Australia. Mark is also the Performance Physiology lead for the Welsh Institute of Performance Science. He has 13 years of experience working in sports and exercise sciences, across a range of settings, including his work as a Senior Physiologist at the Defence and Science Technology Laboratory (Dstl) and as a Sports Scientist in professional Rugby League. Mark is a consultant for various elite sports clubs and institutions around the world and frequently publishes research in the area of human performance.



**Research overview:** Mark's research aims to understand the ways in which applied research can help to improve the health and performance of individuals. This often includes workload monitoring in athletes, as well as the investigation of dietary supplementation and training interventions among both healthy and clinical populations. Specifically, Mark is interested in monitoring athletes or military personnel using wearable micro-technology and enhancing their performance using dietary ergogenic aids or thermal training interventions.

**Postgraduate supervision:** Mark has supervised two PhD students to completion and currently supervises a further ten. These projects include load monitoring using micro-technology in elite athletes, investigations of hyperthermia on cognitive or physical performance and dietary supplements in the heat.

**Research publications:** 100 peer-reviewed publications and 3 invited book chapters. Editorial board member of the *Journal of Science and Medicine in Sport* and Guest Editor for *Sports*. Example publications:

1. Peel, J., McNarry, M., Heffernan, S., Nevola, V. R., Kilduff, L., **Waldron, M.** (2021). The effect of dietary supplements on endurance exercise performance and core temperature in hot environments: a meta-analysis and meta-regression. *Sports Medicine*. DOI:10.1007/s40279-021-01500-2.
2. **Waldron, M.**, Fowler, R., Heffernan, S., Tallent, J., Kilduff, L., Jeffries, O. (2021). Effects of heat acclimation and acclimatisation on maximal aerobic capacity compared to exercise alone in both thermoneutral and hot environments: a meta-analysis and meta-regression. *Sports Medicine*, 51, 1509–1525.
3. **Waldron, M.**, Papavasileiou, G., Jeffries, O., Nevola, V., Heffernan, S. M., Kilduff, L. & Tallent, J. (2020). Concurrent adaptations in maximal aerobic capacity, heat tolerance, microvascular blood flow and oxygen extraction following heat acclimation and ischemic preconditioning. *Journal of Thermal Biology*. doi: 10.1016/j.jtherbio.2020.102724.
4. **Waldron, M.**, Jeffries, O., Patterson, S.D, Tallent, J. & Nevola, V. (2019). The time-course of adaptations in thermoneutral maximal oxygen consumption following heat acclimation. *European Journal of Applied Physiology*, DOI: 10.1007/s00421-019-04218-2.
5. Woodhouse, L., Tallent, J., Patterson, S., & **Waldron, M.** (2021). Elite international female rugby union physical match demands: A five-year longitudinal analysis by position and opposition quality. *Journal of Science & Medicine in Sports*. doi.org/10.1016/j.jsams.2021.03.018
6. **Waldron, M.**, Jones, C., Melotti, L., Brown, R., & Kilduff, L. P. (2021). Collision monitoring in elite male rugby union using a new instrumented mouth-guard. *The Journal of Sports & Exercise Sciences*, 5, 179-187.



Swansea University  
Prifysgol Abertawe

**Dr. Mark Waldron**  
Senior Lecturer in Sport and Exercise Sciences

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Research Centre (A-STEM)**

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**Performance Physiology Lead: Welsh Institute of  
Performance Science**

<https://www.swansea.ac.uk/sports-science/astem/wips/>

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## Professor Liam Kilduff PhD

**Research specialisation:** Performance Science, Strength & Conditioning, Applied Sports Physiology

**Experience:** Professor Kilduff obtained his PhD from Glasgow University examining the effects of Creatine supplementation in sport, health and diseases. He has worked for the last 18 years as a professor of performance science at Swansea University where his research interests focus on elite athlete preparation strategies. He is currently Head of the Applied Sports, Technology, Exercise and Medicine Research Centre (A-STEM) (<https://www.swansea.ac.uk/sports-science/astem/>) and chairs both the Research Steering Group and Strategic Management Board of the Welsh Institute of Performance Science (<https://www.swansea.ac.uk/sports-science/astem/wips/>). He has published over 160 peer reviewed papers and has secured over £3m in research income. He sits on the editorial board of three Sports Science journals.



**Research overview:** Professor Kilduff has worked with various professional rugby organisations for over 15 years, these research collaborations have resulted in numerous publications, PhD completions and grant awards. His current ongoing programme of research involves PhD students who are embedded in professional clubs (e.g., Ospreys and Scarlets) and international teams (e.g., FFR and SRU) to conduct research that has a direct impact of performance.

**Postgraduate supervision:** 15 Masters by research and 6 PhD research students to completion. Currently supervising 5 Masters by research and 5 PhD, students are sponsored by and embedded in elite and professional sports. Topics contribute to research and practice in understanding competition demands, recovery, training modalities and competition day preparation strategies.

**Research publications:** 164 peer reviewed publications (<https://pubmed.ncbi.nlm.nih.gov/?term=kilduff+l>) and 7 invited book chapters. 84 of these papers are in rugby related topics (<https://pubmed.ncbi.nlm.nih.gov/?term=kilduff+l+and+rugby>) Editorial board member of the *European Journal of Sports Science* and the *International Journal of Sports Physiology and Performance*.

### Example publications:

1. Bennett M, Bezodis NE, Shearer DA, **Kilduff LP**. Predicting performance at the group-phase and knockout-phase of the 2015 Rugby World Cup. *Eur J Sport Sci*. 2021 Mar;21(3):312-320. doi: 10.1080/17461391.2020.1743764.
2. Sheppy E, Hills SP, Russell M, Chambers R, Cunningham DJ, Shearer D, Heffernan S, Waldron M, McNarry M, **Kilduff LP**. Assessing the whole-match and worst-case scenario locomotor demands of international women's rugby union match-play. *J Sci Med Sport*. 2020 Jun;23(6):609-614. doi: 10.1016/j.jsams.2019.12.016.
3. Cunningham DJ, Shearer DA, Drawer S, Pollard B, Eager R, Taylor N, Cook CJ, **Kilduff LP**. Movement Demands of Elite Under-20s and Senior International Rugby Union Players. *PLoS One*. 2016 Nov 8;11(11):e0164990. doi: 10.1371/journal.pone.0164990.
4. Crewther BT, Potts N, **Kilduff LP**, Drawer S, Cook CJ. Performance indicators during international rugby union matches are influenced by a combination of physiological and contextual variables. *J Sci Med Sport*. 2020 Apr;23(4):396-402. doi: 10.1016/j.jsams.2019.10.011.



Swansea University  
Prifysgol Abertawe

Liam Kilduff (Ph.D.)  
Professor of Performance Science

Head of the Applied Sports, Technology, Exercise and Medicine Research Centre (A-STEM)

<https://www.swansea.ac.uk/sports-science/astem/>

Chair: Research Steering Group and Strategic Management Board of the Welsh Institute of Performance Science

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## Dr Aaron Uthoff PhD



**Research specialization:** Sports performance and injury prevention with a specialization in developing sprint and change of direction ability

**Experience:** Aaron is a Research Fellow at Auckland University of Technology where he lectures on the principles and applications of strength and conditioning. He is also a strength and conditioning coach specializing in the development of speed and agility for team and individual sport athletes. He received a Master of Science in Performance Psychology from the University of Edinburgh and a Doctor of Philosophy in Sport and Exercise Science from Auckland University of Technology. He is a Certified Strength and Conditioning Specialist with 9 years of experience working with athletes from the youth amateur grades through to Olympic medalists, with stints at the University of Arizona, Scottish Athletics, New Zealand Athletics, and Tauranga Boys' College.

**Research overview:** Cross-pollination of novel physiological and cognitive training techniques to enhance performance and reduce injury risk. My previous research focused on the unique effects of backward running and wearable resistance as tools to mitigate injury and improve physical performance, while my current suite of research is aimed at improving the diagnostic capabilities of change of direction tests, investigating training modalities to optimize striking force in combat athletes, determining the interactions between neck muscle latency and head trauma in rugby athletes, and exploring the role cognitive load has on physical performance.

**Postgraduate supervision:** Currently 5 PhD & 2 Masters students

**Research publications:** 26 peer-reviewed journal articles and 1 book chapter. Examples of Aaron's ongoing work include:

1. Lenetsky, S, **Uthoff, A**, Coyne, J, & Cronin, J. (2021). A review of striking force in full-contact sport athletes: Methods of assessment. *Strength Cond J, Epub Ahead of Print*. DOI: 10.1519/SSC.0000000000000643.
2. Feser, EH, Neville, J, Bezodis, N, Macadam, P, **Uthoff, AM**, Nagahara, R, Tinwala, F, & Cronin, JB. (2021) Waveform analysis of shank loaded wearable resistance during sprint running acceleration. *J Sports Sci*, 39(17), 2015-2022. DOI: 10.1080/02640414.2021.1912966.
3. Forster, J, **Uthoff, A**, Rumpf, MC, Cronin, J. (2021). Advancing the pro-agility test to provide better change of direction speed diagnostics. *J Sport Exerc Sci*, 5(2), 101-106.
4. Feser, EH, Bezodis, NE, Neville, J, Macadam, P, **Uthoff, AM**...Cronin, JB. (2021). Changes to horizontal force-velocity and impulse measures during sprint running acceleration with thigh and shank wearable resistance. *J Sports Sci*, 39(13), 1519-1527. DOI: 10.1080/02640414.2021.1882771.
5. Bustos, A, Metral, G, Cronin, J, **Uthoff, A**, & Dolcetti, J. (2020). Effects of warming up with lower-body wearable resistance on physical performance measures in soccer players over an 8-week training cycle. *J Strength Cond Res*, 34(5), 1220-1226. DOI: 10.1519/JSC.0000000000003498.
6. **Uthoff, A**, Nagahara, R, Macadam, P...& Cronin, J. (2020). Effects of forearm wearable resistance on acceleration mechanics in collegiate track sprinters. *Eur J Sports Sci*, 20(10), 1346-1354. DOI: 10.1080/17461391.2020.1722256.
7. Schofield, M, Tinwala, F, Cronin, J, Hébert-Losier, K, & **Uthoff, A**. (2019). Multijoint musculoarticular stiffness derived from a perturbation is highly variable. *J Strength Cond Res* 35(9), 2498-2503. DOI: 10.1519/JSC.0000000000003186.
8. Macadam, P, Cronin, J, **Uthoff, A**, & Feser, E. (2018). The effects of different wearable resistance placements on sprint-running performance: A review and practical applications. *Strength Cond Res*, 41(3), 79-96. DOI: 10.1519/SSC.0000000000000444.
9. **Uthoff, A**, Oliver, J, Cronin, J, Harrison, C, & Winwood, P. (2018). Sprint-specific training in youth: Backward running vs forward running training on speed and power measures in adolescent male athletes. *J Strength Cond Res*, 34(4), 1113-1122. DOI: 10.1519/JSC.0000000000002914.
10. **Uthoff, A**, Oliver, J, Cronin, J, Winwood, P, & Harrison, C. (2018). A new direction to athletic performance: Understanding the acute and longitudinal responses to backward running. *Sports Med*, 48(5), 1083-1096. DOI: 10.1007/s40279-018-0877-5.

**AUT**

**Dr. Aaron Uthoff**

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## UPDATED MEMBER PROFILES

### Matthew Blair MPhEd (Dist.) BPhEd BSc Dip Tour

**Research specialisation:** Physical conditioning.

**Experience:** Principle Lecturer, Coordinator, Academic Leader - Postgraduate Diploma Applied Science (Physical conditioning), Otago Polytechnic. Consultant for World Rugby High Performance (2011-2019). Currently working with Club Rugby in Dunedin as a volunteer.

**Research overview:** Matt's rugby research includes performance technology, wellness profiling and load measurement with fifteens, 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 and Tokyo, Japan (Current).

Semisi Fonua (Tonga Rugby Lead S&C) – Training Load 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:

1. Elsworthy, N., Blair, M., & Lastella, M. (2021). On-field movements, heart rate responses and perceived exertion of lead referees in Rugby World Cup matches, 2019. *Journal of Science & Medicine in Sport*, 24, 386-390.
2. 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.
3. 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
4. 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*.
5. 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.
6. 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*.
7. 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
8. Blair, M. (2017). Considerations for Rugby Sevens-specific training schedules. *Scope (Activity & Health)*, 1.



#### Mat Blair (PhD)

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## Prof. Mike Hamlin PhD(Otago), MHMS (Uni of Queensland), BPhEd (Otago).

**Research specialisation:** Exercise Physiology, Training, Altitude and Hypoxia, Injury

**Experience:** Over 20 years of research experience into elite and sub-elite sportspeople. Worked with athletes from Bike NZ, Triathlon NZ, NZ Rugby, and Canterbury Rugby, Netherlands Triathlon Team. Fellow of the American College of Sports Medicine, Fellow of the European College of Sport Science and Fellow of Sport Science New Zealand.

**Research overview:** Mike's research areas include exercise physiology, the health effects of physical activity and performance-related aspects of elite athletes, in particular the use of altitude and hypoxic training to enhance performance. Mike has been involved in a number of altitude training projects (both real and simulated); with a number involving rugby players. More recently, Mike has conducted a number of projects on athletes using intermittent hypoxic training. Mike's research also involves analysing the training effects and how these affect stress within the athlete and how this can be monitored to and used to improve training response and recovery.

**Postgraduate supervision:** Currently supervising three PhD students in the areas of flexibility and training effect on health and performance, internal and external load parameters in elite team sport athletes and exercise with chronic kidney disease patients.

**Research publications:** 115 peer reviewed publications, over 100 conference presentations and 1 book. Editor for the following publications; Journal of Sport and Exercise Science, Frontiers in Sports and Active Living -Elite Sports and Performance Enhancement, Slovak Journal of Sports Science, Archives of Allied Health Sciences. Example publications:

1. **Hamlin, M.J.**, Deuchrass, R.W., Olsen, P.D., Choukri, M.A., Marshall, H.C., Lizamore, C.A., Leong, C., Elliot, C.A. The effect of sleep quality and quantity on athlete's health and perceived training quality. *Frontiers in Sports and Active Living* 3:705650, 2021.
2. **Hamlin, MJ.** Lizamore, CA. Olsen, PD. Marshall, HC. Monitoring heart rate variability and subsequent performance in team-sport athletes receiving hypoxic or normoxic repeated sprint training. *Archives of Allied Health Science* 33(1) 9-18, 2021.
3. Busbridge, A.R. **Hamlin, M.J.** Jowsey, J.A. Vanner, M.H. and Olsen, P.D. Running demands of provincial women's rugby union matches in New Zealand. *Journal of Strength and Conditioning Research (In Press)*.
4. **Hamlin, MJ.** Deuchrass, RW., Elliot, CE., Manimmanakorn, N. Short and long-term differences in anthropometric characteristics and physical performance between male rugby players that became professional or remained amateur. *Journal of Exercise Science and Fitness* 19 143-149 2021. <https://doi.org/10.1016/j.jesf.2021.01.002>
5. Muangritdech, N., **Hamlin, M.J.**, Sawanyawisuth, K., Prajumwongs, P., Saengjian, W., Wonnabussapawich, P., Manimmanakorn, N., Manimmanakorn, A. Hypoxic training improves blood pressure, nitric oxide and hypoxia-inducible factor-1 alpha in hypertensive patients. *European Journal of Applied Physiology* 120(8) 1815-1826, 2020.
6. **Hamlin, M.J.**, Deuchrass, R. Elliot, C.E., Raj, T. Promkeaw, D. Phonthee, S. Effect of a 6-week exercise intervention for improved neck muscle strength in amateur male rugby union players. *The Journal of Sport and Exercise Science* 4(1) 33-39, 2020.
7. Takamori, S., **Hamlin, M.J.** Kieser, D.C., King, D., Hume, P., Yamazaki, T., Hachiya, M., Olsen, P.D. Senior club-level rugby union player's positional movement performance using individualised velocity thresholds and accelerometer-derived impacts in matches. *J Strength & Conditioning Research* (DOI: [10.1519/jsc.0000000000003523](https://doi.org/10.1519/jsc.0000000000003523))



### Mike Hamlin (PhD)

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## Dr Jenny Gregory PhD, BSc

**Research specialisation:** Biomedical image analysis of the musculoskeletal system.

**Experience:** A specialist in biomedical image analysis, particularly the use of radiographs, DXA and MRI in musculoskeletal disorders and development. Currently a Lecturer in Sports Science at the University of Aberdeen in Scotland UK. Previously an MRC New Investigator, researching links between bone shape and osteoarthritis.

**Research overview:** The use of biomedical images and data in the study of musculoskeletal disorders. Interested in understanding how bone shape and structure is determined and changes throughout our lives particularly where it can be related to osteoarthritis, fracture, physical activities and injuries.

**Postgraduate supervision:** Have supervised 3 PhD students to completion, as well as several MSc students.

**Research publications:** Published over 50 peer reviewed journal articles and 1 book chapter.

Example publications:

1. Faber B.G., Ebsim R, Saunders, F.R., Frysz M., Gregory, J.S. Aspden, R.M. Harvey N.C., Smith, G.D. Cootes, T.F. Lindner, C. Tobias, J.H. (2021) Cam morphology but neither acetabular dysplasia nor pincer morphology is associated with osteophytosis throughout the hip: findings from a cross-sectional study in UK Biobank, *Osteoarthritis and Cartilage* <https://doi.org/10.1016/j.joca.2021.08.002>
2. Nicod, J., Davies, R. W., Cai, N., Hassett, C., Goodstadt, L., Cosgrove, C., . . . Flint, J. (2016). Genome-wide association of multiple complex traits in outbred mice by ultra-low-coverage sequencing. *Nat Genet*, 48(8), 912-918. doi:10.1038/ng.3595
3. Gregory, J. S., Barr, R. J., Varela, V., Ahearn, T. S., Gardiner, J. L., Gilbert, F. J., . . . Aspden, R. M. (2016). MRI and the distribution of bone marrow fat in hip osteoarthritis. *J Magn Reson Imaging*. doi:10.1002/jmri.25318
4. Nelson, A. E., Golightly, Y. M., Renner, J. B., Schwartz, T. A., Liu, F., Lynch, J. A., . . . Jordan, J. M. (2016). Variations in Hip Shape Are Associated with Radiographic Knee Osteoarthritis: Cross-sectional and Longitudinal Analyses of the Johnston County Osteoarthritis Project. *J Rheumatol*, 43(2), 405-410. doi:10.3899/jrheum.150559
5. Varzi, D., Coupaud, S. A., Purcell, M., Allan, D. B., Gregory, J. S., & Barr, R. J. (2015). Bone morphology of the femur and tibia captured by statistical shape modelling predicts rapid bone loss in acute spinal cord injury patients. *Bone*, 81, 495-501. doi:10.1016/j.bone.2015.08.026
6. Goodyear, S. R., Barr, R. J., McCloskey, E., Alesci, S., Aspden, R. M., Reid, D. M., & Gregory, J. S. (2013). Can we improve the prediction of hip fracture by assessing bone structure using shape and appearance modelling? *Bone*, 53(1), 188-193. doi:10.1016/j.bone.2012.11.042
7. Barr, R. J., Gregory, J. S., Reid, D. M., Aspden, R. M., Yoshida, K., Hosie, G., . . . Macfarlane, G. J. (2012). Predicting OA progression to total hip replacement: can we do better than risk factors alone using active shape modelling as an imaging biomarker? *Rheumatology (Oxford)*, 51(3), 562-570. doi: 10.1093/rheumatology/ker382



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## Dr Sayumi Iwamoto

Toyo University Prof. PhD (Sports Science),  
ISAK Level 3, Athletic Trainer (JSPO), Training Instructor (JATI)

**Research specialisation:** Sports injury prevention, Athlete conditioning, Sports injury epidemiology; Ankle sprain biomechanics in tennis. Female athlete triad.

**Experience:** Being an athletic trainer with 30yrs experience in professional baseball players, golf players, tennis players, keirin racers and jockeys. Managed amateur male and female long-distance, basketball, volleyball, junior rugby, and tennis teams. Holding seminars to spread the knowledge of Kinanthropometry (ISAK method Level 1 and 2) in Japan sports field. Teaching sports science at Toyo university since 2006. Associated researcher at Auckland University of technology since 2012.

**Research overview:** Focus on researching injury prevention in sports through surveillance study, investigating injury mechanisms at the amateur and junior level of participation to propose proper prevention exercises. Researching on conditioning for female athlete triad on Japanese long-distance runners to provide the correct preventive measures and help. Measuring anthropometry on Japanese rugby top level players for understanding and creating the base line.

**Postgraduate supervision:** Currently supervising Master students at Toyo university with topics of sports injuries and practice of Chinese university high-level table tennis players.

### Research publications:

1. Nakajima, T., Kagawa, M., Takata, I. K., T., Ohta, Hoshino, Y., and **Iwamoto, S.**, A comparison of anthropometric characteristics among competition level on Japanese college rugby player. *Football Science* (2021) **18**;15 – 21 (In Japanese)
2. **Iwamoto, S.**, Takata, I. K., Ohta, C., Sugita, K., and Takata, I. K., Preseason physique control in elite rugby team: Case report using skinfold and Leanness ratio score. *Journal of training science for exercise and sport* (2020) **32**(4);265-272 (In Japanese)
3. **Iwamoto, S.**, Nakajima, T., Takata, I. K., Ohta, C., Futagami, M., Hiramatsu, W., Hume, P., and Kagawa, M. Application of data from physical measurements in conditioning for rugby player. *Japanese Society for Athletic Training* (2019) **5**(1);53-61 (In Japanese)
4. **Iwamoto, S.** Shoulder and elbow injuries in tennis. *Japanese Society for Athletic Training* (2019) **4** (2); 127-135 (In Japanese)
5. **Iwamoto, S.**, and Futagam, M. Background of students who aim to get certified athletic trainer qualification, things that are seen from on-site training and hope for the future. *Japanese Society for Athletic Training* (2018) **4** (1);77-88 (In Japanese)
6. **Iwamoto, S.**, Takata, I. K., Ohta, C., Hume, P., Shaw D., Kara S., and Kagawa, M. Anthropometric data and somatotypes of Japanese university rugby players-Position characteristics of forward players and back players- *Journal of Training Science for Exercise and Sport* (2018). **29**;143-152 (In Japanese)
7. **Iwamoto, S.**, and Kanamori, A. A university tennis player returning to the game after an ACL injury and choosing non-operative rehabilitation protocol: A case report *Japanese Journal of Tennis Science* **25** (2017); 103-119 (In Japanese).



### Sayumi Iwamoto (PhD)

Professor, Sports Science and Department  
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SPRINZ Research associate, AUT.

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東洋大学



## Dr Trevor Clark PhD, MSc, BA (Hons)

**Research Specialisations:** Sport performance, injury epidemiology and strength and conditioning.

**Experience:** Currently Dean (Undergraduate) at the International College of Management Sydney. Trevor has 35 years' experience in sport, education, and coaching. Previously worked with the NZ Warriors (High Performance Coach), North Harbour Rugby (Strength and Conditioning), and Windsor Wolves (NSW Cup, Defence Coach / Strength and Conditioning). ASCA Accredited L3 Elite Strength and Conditioning Coach and ESSA Accredited L2 Sport Science, Exercise Science and High-Performance Management. Played rugby league professionally in England (12 years) amassing 275 games for Leeds, Featherstone, and Bradford.



**Research overview:** Main area of interest is focused on improving sport performance and on reducing sporting injuries and investigating mechanisms of injury. Technology is transforming the way coaches, teams and individual athletes track, monitor, and improve performance. Whilst sports performance receives attention from multiple sources of funding at the state and national level there is a paucity of research evidence available looking specifically at the recovery, regeneration, and well-being of athletes at all levels of engagement. This is an area where more investigations are required to help improve mental well-being, reduce stress, anxiety, and feelings of depression for athletes in competitive environments and/or transitioning into retirement from sport. In recent years Trevor has been involved with several concussion papers in contact sport. His doctoral thesis was the first health study looking specifically at Māori players retired from competitive rugby league participation.

### Research publications:

1. King, D., Hume, P., **Clark, T.**, Fosskett, A. & Barnes, M. (2021). Training injury incidence in an amateur women's rugby union team in New Zealand over two consecutive seasons. *Journal of Science and Medicine in Sport* 24 (2021) 544–548.
2. King, D., Hume, P., **Clark, T.**, Hind, K & Hardaker, N. (2020). Concussion Reporting and Return to Play over Two Years for an Amateur Women's Rugby Union Team in New Zealand. *Advances in Orthopaedics and Sports Medicine*, Volume 2020, Issue 04.
3. King, D., Hume, P., **Clark, T.**, Fosskett, A. & Barnes, M. (2020). Incidence of Match Injuries in an Amateur Women's Rugby Union Team in New Zealand over Two Consecutive Seasons. *Advances in Orthopaedics and Sports Medicine*, Volume 2020, Issue 02.
4. King, D., Hume, P., **Clark, T.** & Pearce, A. (2020). Use of the King-Devick test for the identification of concussion in an amateur domestic women's rugby union team over two competition seasons in New Zealand. *Journal of the Neurological Sciences* 418 (2020) 117162
5. King, D., Hume, P., Cummins, C., Pearce, A., **Clark, T.**, Fosskett, A., & Barnes, M. (2019). Match and Training Injuries in Women's Rugby Union: A Systematic Review of Published Studies. *Sports Medicine* (2019) 49:1559–1574 <https://doi.org/10.1007/s40279-019-01151-4>
6. King, D., Hume, P., Hardaker, N., Cummins, C., Pearce, A. & **Clark, T.** (2019). Traumatic brain injuries in New Zealand: National Insurance (Accident Compensation Corporation) claims from 2012 to 2016. *Journal of the Neurological Sciences*; <https://doi.org/10.1016/j.jns.2019.01.049>
7. King, D., Hume, P., Hardaker, N., Cummins, C., **Clark, T.**, Pearce, A. & Gissane, C. (2019). Female rugby union injuries in New Zealand: A review of five years of Accident Compensation Corporation moderate to severe claims and costs. *Journal of Science Medicine Sports*. 22 (2019) 532-537
8. King, D., Hume, P., Gissane, C., **Clark, T.** & Cummins, C. (2018). Injuries in a senior amateur rugby union team over two competition seasons resulted in a ratio of 1:5 witnessed to unwitnessed concussions. *NZ Journal Sports Medicine*. 2018. 45(1):22-33
9. King, D., Cummins, C., Hume, P. & **Clark, T.** (2018). Physical demands of amateur domestic and representative netball in one season in New Zealand assessed using heart rate and movement analysis. *Journal of Strength Conditioning Research*. 2018. doi: 10.1519/JSC.0000000000002605
10. King, D., Hume, P., Hardaker, N., Cummins, C., Gissane, C. & **Clark, T.** (2018). Sports related injuries in New Zealand: National insurance (Accident Compensation Corporation) claims for five sporting codes from 2012 to 2016. *British Journal of Sports Medicine*. 2018. doi: 10.1136/bjsports-2017-098533
11. **Clark, TN.**, & King, D. (2017). Incidence of training injuries in a New Zealand amateur rugby league team over three consecutive years. *Australian Journal of Strength Conditioning*. 25 (7) 26-31.



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## Dr Scott Brown PhD, BSc, MSc (Hons), PhD

**Research specialisation:** Sports biomechanics, strength and conditioning, coaching, injury prevention, and technology design.

**Experience:** > 40 peer-reviewed journal publications (including primary and co-authored works); academic journal reviewer for 8 peer-reviewed journals; Head Strength and Conditioning and Assistant Coach Aquinas College Rugby (Men and Women), Head Coach (Women), East Coast Bays Rugby Football Club (union) and Conditioning Coach (Women), North Harbour Rugby Union and sevens; implementer of the SPRINZ return-to-sport clinical service; product design and testing with the AUT School of Engineering and School of Sport and Recreation; international collaborations with Professor Jean-Benoît Morin from Université Côte d'Azur in Nice, FRA, Dr. Pedro Jiménez-Reyes from Universidad Católica San Antonio de Murcia, Murcia, ESP and Professor Aaron Coutts from University of Technology Sydney, Sydney, AUS.



**Research overview:** Strength and conditioning practice and team sport application; three-dimensional biomechanics and motion capture techniques; electromyography and dynamic muscle function; software design and sport implementation.

**Postgraduate supervision:** Three masters theses students to completion; unpaid work and official capacity. The effects of 8-weeks training programme of plyometric and ballistic training on female golfers' physical characteristics and drive performance by Anita Ya Ting Chau. [MSc completed]. An Analysis of High-bar and Low-bar Back-squat Techniques in Olympic Weightlifters and Powerlifters by Daniel Glassbrook. [MSc completed]. The Effects of Handheld Load on Horizontal Jump Performance in Female Athletes by Chloe R McKenzie. [MSc completed].

### Research publications:

1. **Brown SR**, Washabaugh EP, Dutt-Mazumder A, Wojtys EM, Palmieri-Smith RM, Krishnan C. Functional resistance training as a viable method to improve lower-extremity strength and gait mechanics in an individual with acute anterior cruciate ligament-reconstruction. *Sports Health*. 2019.
2. **Brown SR**, Feldman ER, Cross MR, Helms ER, Marrier B, Samozino P, Morin J-B. The potential for a targeted strength training programme to decrease asymmetry and increase performance: A proof-of-concept in sprinting. *Int J Sports Physiol Perform*. 2017.
3. **Brown SR**, Brughelli M, Cross MR. Profiling sprint mechanics by leg preference and position in rugby union athletes. *Int J Sports Med*. 2016;37:890-897.
4. **Brown SR**, Brughelli M, Bridgeman LA. Profiling isokinetic strength by leg preference and position in rugby union athletes. *Int J Sports Physiol Perform*. 2016;11:500-507.
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## AQUINAS COLLEGE

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## Dr. Victor Lopez, Jr., D.O.

**Research specialization:** Sports injury epidemiology and prevention, Olympic rugby development player's injury risk, in a strategic growing rugby market.

**Experience:** Prior to collaborations with AUT/SPRINZ since 2014, Dr. Lopez was surgically trained in the North Shore-LIJ Hospital System, NY (currently Northwell Health), is a current Clinical Affiliated Investigator, and the Founder and Executive Director of the Research Institute for Sports and Exercise (RISE Institute), at [Hospital for Special Surgery \(HSS\)](#) an International Olympic Committee-Medical Centre, he also Founded and is Executive Director of the Rugby Research and Injury Prevention Group (2009-21) ([www.rugbyinjury.org](http://www.rugbyinjury.org)), and Director of Medical Services for the [Northeast Academy](#) (2014-2019), a USA Rugby Sanctioned Development Academy, with its elite team, the [New York City World Club 7s Squad](#), and the youth-aged US Olympic Committee, Community Olympic Development Programme (USOC-CODP). That travelled the North American playing circuit (Barbados, Costa Rica, Canada & the USA) Teaching spans high school advanced science program, undergraduate to post-graduate residents in Sports Medicine and Surgery. Dr Lopez has presented at major sports conferences; AOSSM, ACSM, BASES, ISAKOS, ISBS, SMA and the IOC World Conference on Prevention of Injury and illness in Sport. In 2019 he chaired the [SMA Symposium on Rugby Union 7s and 15s Injury Prevention](#) Symposium anchored by Prof Patria Hume. In 2021 Dr. Lopez will be the Rugby-7s IOC workshop co-presenter with his colleague Dr Richard Ma, on Rugby-7s Injury prevention, guided by his mentor Prof Patria Hume. Dr Lopez's combination of rugby science/sports medicine with rugby playing experience enables an understanding of the needs in safety and injury prevention.

**Research overview:** Dr. Lopez conducts rugby research (amateur to elite) across North America. Despite its growing popularity in the U.S., there is a lack of rugby-related injury data on North America. This is due in part to the sport being predominantly a club sport, as well as lack of inclusion in existing injury surveillance systems. His aims are to gain a preliminary data set of rugby knowledge on safety, player history, past injuries and mechanisms of injury; and ascertain trends to assist in player welfare and safety; and apply the [Rugby Injury Survey and Evaluation \(RISE\)](#) data collection methodology. Which has matured to a 10-year dataset, this 2021, on US injury data. To assist healthcare providers to understand the risk factors for rugby-related injuries and make safe return-to-play decisions and decrease the likelihood of re-injury to players. This may in turn, nurture the development of the large pool of athletic talent to progress from youth rugby to the elite level and possible national candidates. Dr Lopez is fortunate to be working towards his PhD at AUT/SPRINZ, on "Risk factors in US Rugby-7s" with supervisors, [Dr. Answorth A. Allen](#), the concussion expert [Dr. Robert C Cantu](#), Professor Meryle Weinstein & Professor Patria Hume. He works closely with [USA Rugby](#) and the [Empire Geographic Union \(GU\)](#) RFU & [New England GU](#) RFU. As Co-Principle Investigator of a 2-year prospective injury epidemiological study of Rugby-7s in North America, sponsored by [Hospital for Special Surgery](#) and the [National Operating Committee on Standards for Athletic Equipment](#), he attends greater than 50 USA Rugby sanctioned U.S. tournaments, including the [USA Rugby Club Championships](#) (for 10 years) and other major events: [HSBC Las Vegas Rugby-7s](#) and the [Penn Mutual Collegiate Rugby Championships](#).

**Postgraduate supervision:** Multiple residents and Fellows senior papers, 2 Masters research students to completion. Currently supervising 3 Masters: Application of an injury prevention programme for U.S. Rugby; Rugby-7s risk in a multiple match format.

**Research publications:** Examples representative of Dr. Lopez's previous and ongoing work include:

1. **Lopez V, Jr.,** Ma, R, Weinstein MG, Hume PA, Cantu RC, et al. Effects of U.S. Rugby-7s players' competition level and playing position on injury incidence, severity and characteristics: a prospective cohort study of pre-professional injury rates. *CJSM*. (to be submitted Nov 2021)
2. **Lopez V, Jr.,** Ma, R, Weinstein MG, Hume PA, Cantu RC, et al. United States Rugby-7s under-19 tournament players injury rates during a 5-year epidemiological study. *Sports Med Open*. 2020 Aug 27;6(1):41. doi: 10.1186/s40798-020-00261-y
3. **Lopez V, Jr.,** Victoria C, Ma R, Weinstein MG, Hume PA, Haleem SY, Mettry MT, Quteishat B & Allen AA. Prevalence and Cause of Non-contact Injury Mechanisms in US Men's Rugby-7s. *ISBS Proceedings Archive*: 2019 Vol.37, 1:44 At: <https://commons.nmu.edu/isbs/vol37/iss1/44>.
4. **Lopez V, Jr.,** Ma, R, Weinstein MG, Hume PA, Cantu RC, Victoria C, Haleem SY, DeLallo JF & Allen AA. Biomechanical Contact Injury Influences in USA Men's Rugby-7s. *ISBS Proceedings Archive*: 2018 Vol.36, 1:125. At: <https://commons.nmu.edu/isbs/vol36/iss1/125>.
5. Ma R, **Lopez V, Jr.,** Weinstein MG, Chen JL, Black CM, et al. Injury Profile of American Women Rugby-7s. *MSSE*. 2016 Oct;48(10):1957-66. PMID:27232243
6. **Lopez V, Jr.,** Ma, R, Weinstein MG, Cantu RC, Myers LSD, et al. Concussive Injuries in Rugby-7s: An American Experience and Current Review. *MSSE* 2016 Jul;48(7):1320-30. PMID: 26829001
7. **Lopez Jr. V,** Ma R, Weinstein MG, Chen JL, Black CM, et al. An American Experience with a New Olympic Collision Sport: Rugby-7s. *OJSM*. 2014 Jul; 2(2S); DOI: 2325967114S00056.
8. **Lopez V, Jr.,** Galano GJ, Black CM, Gupta AT, James DE, Kelleher, K, Allen AA. Profile of an American Amateur Rugby Union Sevens Series. *AJSM*. 2012; 40(1):179-184. PMID: 22102102



**Rugby Research & Injury Prevention Group**

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## PROJECT UPDATES

### Rugby anthropometry by Professor Sayumi Iwamoto's team

*Iwamoto, S., Takata, I. K., Ohta, C., Sugita, K., and Takata, I. K., Preseason physique control in elite rugby team: Case report using skinfold and Leanness ratio score. Journal of training science for exercise and sport (2020) 32(4);265-272 (In Japanese)*

This is a short report in which skinfold measurement is used in pre-season physical fitness test for the elite rugby team. Leanness ratio score was used as target value of the proper body composition of the rugby player. Twenty-six participations belong to super rugby team, in condition of joining the physical fitness test twice the pre-season and in-season. Based on The International Society for the Advancement of Kinanthropometry standards: height, body weight and eight items of skinfold were measured. At the start of the pre-season, a large individual variation in physique on Forward (FW) and Backs (BK) was confirmed. The target value of the Leanness ratio score was set at 0.8 for FW and 1.0 for BK, respectively. For the players with below the target value, training for physique control was added to the normal training of the team (physical control training group). For the physique TR group, the FW of the Leanness ratio score could reach the target value (0.84), while the BK could not (0.79). Although the Leanness ratio score has little evidence at present, it can be expected to expand its potential as a conditioning index by further case studies.

*Nakajima, T., Kagawa, M., Takata, I. K., T., Ohta, Hoshino, Y., and Iwamoto, S., A comparison of anthropometric characteristics among competition level on Japanese college rugby player. Football Science (2021) 18;15 – 21 (In Japanese)*

Anthropometric characteristics have been considered as useful indicators for athletic performance in rugby. However, there has been no detailed report on anthropometric characteristics of Japanese college rugby players. The purpose of this study was therefore to investigate differences in anthropometric characteristics of college rugby players who participate in different competition levels. A total of 101 players that consist of 49 forwards (FWs: aged  $20.4 \pm 1.4$  years old,  $10 \pm 3.5$  years of participation) and 52 backs (BKs: aged  $19.8 \pm 1.3$  years old,  $11.5 \pm 4.0$  years of participation) from a college rugby team participated the study. Participants were categorized into official competition members (Sr) (19 FWs and 20 BKs) and the rest (Jr) (30 FWs and 32 BKs). Anthropometry using the ISAK protocol (stature, body mass and eight skinfolds) and a body composition assessment using the underwater weighing (UWW) were conducted. Anthropometric indices (sum of upper limb skinfolds [US], sum of trunk region skinfolds [TS], sum of lower limb skinfolds [LS], sum of eight skinfolds [ $\Sigma 8SF$ ], body mass index [BMI] and lean mass index [LMI] were calculated from anthropometry while a percentage body fat [%FAT] and lean body mass [LBM] were estimated from the UWW. Both FWs and BKs showed significant differences in stature, US, LS,  $\Sigma 8SF$ , LMI, and LBM between Sr and Jr players ( $p < 0.05$ ). In addition, JrBKs had significantly ( $p < 0.05$ ) greater %FAT compared with Sr BKs. The present study revealed differences in anthropometric characteristics in college rugby players of different competition levels.

### Head impact biomechanics research by Doug King's research team

*King, D., Hume, P.A., Brughelli, M. and Gissane, C. Instrumented mouthguard acceleration analyses for head impacts in amateur rugby union players over a season of matches. Am J Sports Med, 2015 43(3): 614-624*

Our study was conducted to explore and describe the magnitude and frequency of head impacts sustained by a single amateur senior premier rugby union team. By utilising accelerometer fitted mouthguards in a single premier team throughout the 2013 domestic season of matches there were 20,687 impacts recorded above 10g. Although the inter-study comparisons showed that the frequency of impacts recorded were in the low injury impact severity limit ( $< 66g$  and  $< 4,600 \text{ rad/s}^2$ ), the comparison studies utilised different formats of accelerometer fitted equipment. Mean linear acceleration measured over the season of matches was like mean linear accelerations reported in studies for American high school football, some American collegiate football, but lower than female soccer youths. Mean rotational accelerations measured were higher than American youth, high school and collegiate football, but lower than female youth soccer. Most of the linear and rotational acceleration impacts recorded in senior amateur rugby union fall into the mild category of impact severity.

**King, D., Hume, P.A., Gissane, C., Brughelli, M. & Clark, T.N. The influence of head impact threshold for reporting data in contact and collision sports: Systematic review and original data analysis. *Sports Med*, 2016. 46(2): 151-161**

This study identified the methodological differences in the threshold limits of impacts to the head as a result of participation in contact sports. Of the 34 studies, 39% reported impacts at the 10g impact threshold while 22% of studies used the 14.4g impact threshold. Resultant linear accelerations were most frequently reported (91%) while 76% reported resultant rotational accelerations. Three-quarters (74%) of studies reported both resultant linear and rotational accelerations. Impact data were most frequently (52%) reported as mean  $\pm$  standard deviation ( $\pm$ SD). Some (10%) studies reported the head impact data as median, but not all (4%) included the interquartile ranges (IQR) for these data. The influence of head impact thresholds was shown using head impact data obtained from 38 senior amateur rugby union players during 19 matches in New Zealand. Application of the varied impact thresholds resulted in 20,687 impacts >10g; 11,459 (44.6% less), impacts >15g; and 4,024 (80.5% less) impacts >30g. Given head impacts are likely to cause concussive injury, and the number of head impacts may be related to a potential concussion threshold (i.e. a cumulative threshold), the number and severity of head impacts should be monitored in players. However, impacts can be measured with several technologies (e.g. instrumented behind the ear patches, mouthguards, head gear), and thresholds have differed for reporting impact data in contact and collision sports. Consensus is therefore required to identify the reporting modalities (e.g. linear threshold, descriptive calculations), utilised in future impact studies to enable between study comparisons. Until in-field validation studies are completed, it is recommended that data should be reported as mean  $\pm$  standard deviation, median and interquartile ranges using the 10g impact threshold

**King, D. Hume, P.A., Clark, T.N. & Gissane, C. Does playing away from home influence the number and severity of impacts in amateur rugby union players: Analyses by home/away, won/lost and first/second season halves. *Ann Sports Med Res*, 2020. 7(3): 1150**

Front-row forwards (FRF) recorded more impacts to the head at away games (4,690) when compared with home (2,311) games. Back-row forwards recorded more impacts to the head in games won (4,890) when compared with games lost (1,642). Outside backs recorded a longer impact duration in the first- ( $7.6 \pm 5.7$  ms), when compared with the second-half ( $6.2 \pm 3.9$  ms) of the season. Male rugby players have been reported to have the greatest improvement in strength, flexibility, and aerobic fitness during the pre-season, before returning to baseline during the competitive season. This reduction may also occur towards the end of a season due to low training loads, injury rates and high match loads. This may have been the case with the current cohort where the median resultant linear ( $15.2$  g vs.  $13.2$  g) acceleration recorded was lower in the second half of the season but the median resultant rotational ( $2,141$  rad/s<sup>2</sup> vs.  $2,231$  rad/s<sup>2</sup>) accelerations were higher.

**King, D., Hume, P.A., Gissane, C. & Clark, T. Head impacts in a junior rugby league team measured with a wireless head impact sensor: An exploratory analysis. *J Neurosurg Pediatr*, 2017. 19(1): 13-23**

By utilising accelerometer fitted patches worn behind the ear of participants in a single rugby league junior team throughout the 2014 match competition season, there were 1,977 impacts recorded. Mean linear acceleration measured over the season of matches was like mean linear accelerations reported in studies for American Pop Warner and Youth football. Mean rotational accelerations measured were higher than American Pop Warner, youth, and high school football. Further studies should explore impacts at the senior, female, and professional levels of participation. Although we reported the data by means ( $\pm$ SD), median [IQR] and 95<sup>th</sup> percentile to enable comparisons across published studies, there is a need for standardization of reporting head impact biomechanics to enable accurate comparisons.

**King, D., Hume, P.A., Gissane, C. & Clark, T. Head impact acceleration measured with instrumented ear patches in a junior rugby union team during matches were similar to other sports. *J Neurosurg Pediatr*, 2016 18(1): 65-72**

Median linear acceleration measured over four matches for an under-9 rugby union team was similar to median linear accelerations reported in studies for American Pop Warner and Youth football. Median rotational accelerations were higher than American Pop Warner and Youth football. There is a need for standardization of reporting head impact biomechanics to enable accurate comparisons across published studies.

**King, D., Hume, P.A., Gissane, C. & Clark, T. Measurement of head impacts in a senior amateur rugby league team with an instrumented patch: Exploratory analysis. *ARC J Res Sports Med*, 2017. 2(1): 9-20**

The study was conducted to describe the magnitude, frequency and distribution of head impacts sustained by a single amateur senior premier rugby league team over a competition season of matches. By utilising accelerometer fitted patches applied behind the ear of players in a single premier team throughout the 2014 and 2015 domestic seasons of matches there were 20,837 impacts recorded. Median linear accelerations were lower than high school and collegiate American football while the median rotational accelerations were higher. Further studies should further explore head impact characteristics at all levels of participation in rugby league.

**King, D., Hume, P.A., Gissane, C., Keiser, D. & Clark, T. Head impact exposure from match participation in women's rugby league over one season of domestic competition. *J Sci Med Sport*, 2018. 21(2): 139-146**

Female rugby league athletes were exposed to repetitive sub-concussive head impacts with an average of 14 significant impacts per-player per-match. Forwards were exposed to significantly more impacts per-match than backs and these impacts tended to be of greater magnitude. Most impacts occurred on the side of the head and were sustained during the second half of the game.

**King, D., Hecimovich, M., Clark, T. & Gissane, C. Measurement of the head impacts in a sub-elite Australian Rules football team with an instrumented patch: An exploratory analysis. *Int J Sports Sci Coach*, 2017. 12(3): 359-370**

For the first time, the head impact biomechanics experienced with participation in Australian Football league matches was measured. Using instrumented mastoid-based impact sensors (accelerometer) over the course of a single season 4,903 impacts were recorded. Players experienced  $30 \pm 38$  impacts per-player per-match with 14 impacts recorded above the linear injury risk limit, and 436 impacts about the rotational injury risk limit signifying that some impacts above the suggested 95g and 5500 rad/s<sup>2</sup> are occurring. In comparison to the rugby and American football players in this study were subjected to less overall impacts and high-risk impacts. However, inter-code comparisons are complex, and the value of this comparison is at the individual level, where the contribution of sub-concussive impacts may lead to impairment on clinical measures of neurologic function. The key to this study was obtaining and thus gaining initial measurements on the frequency, magnitude, distribution, and risk weighted exposure of head impacts in Australia Rule Football to assist in the identification at-risk players which will better inform medical personnel of the need to evaluate a player for concussion.

**Hecimovich, M., King, D., Dempsey, A. & Murphy, M. Head impact exposure in junior and adult Australian football players. *J Sports Med (Hindawi Publ Corp)*, 2018. 2018: 8376030**

There were similar results between the two levels of play in median linear and rotational acceleration with the senior players recording slightly higher values in both areas. Obtaining head impact mechanics with the use of accelerometer sensors allows comparison between various levels of play in ARF. This is vital as those in the younger levels, whose brain are still developing and possibly more susceptible to injury. In this study, the players at the junior level recorded similar levels of impact to those in the adult level. Due to this future research needs to address safety issues at the lower levels to ensure less traumatic impacts to the younger players.

**Hecimovich, M., King, D. & Garrett, T. Accelerometric analysis of head impacts in amateur wrestling: An exploratory analysis. *Int J Wrestl Sci*, 2016. 6(2): 117-126**

Presented to the International Scientific and Professional Conference on Wrestling organized by the Faculty of Kinesiology, University of Zagreb and the Faculty of Sports and Physical Education, University of Novi Sad and under the auspices of the International Network of Wrestling Researchers (INWR), the United World Wrestling (UWW) and the International Association of Sport Kinetics (IASK) held at the Faculty of Sports and Physical Education in Novi Sad, Zagreb, Serbia in 2017 (ISBN: 978-86-6353-022-5). Due to the exploratory nature of this study, small sample size and the absence of a diagnosed concussion, the results are to be viewed with caution, as it is unclear of the generalizability of the data. Results indicate lower levels in all measurements compared to football and rugby. Interestingly the back of the head recorded higher median peak linear accelerations than the side that may be the result of takedown manoeuvres. This may have also contributed to the higher median RWECP of the top right side of the head than of the front right side. The key to this study was obtaining and thus gaining initial measurements on the frequency, magnitude, distribution and risk weighted exposure of head impacts in collegiate wrestling in

order to assist in the identification of at-risk wrestlers and better inform medical personnel of the need to evaluate an athlete for concussion

*King, D. A., P. A. Hume, C. Gissane and T. Clark (2021). "Impacts to the head in a premier one domestic netball team measured with a wireless head impact sensor over a domestic competition season: an exploratory analysis." J Orthopaedic Research and Surgery 2(2).*

Although the game of netball is considered a non-contact sport it is evident from data presented in this study, that players can experience significant head impacts capable of causing clinical concussion. Furthermore, they experience repetitive head impacts in excess of sub-concussive thresholds. Head impact frequency and magnitude are player position dependent. The players in the centre position are more exposed to impacts because of the pivotal role and freedom of movement in all thirds of the court. However, these impacts may not be as severe compared to players in attack and defence positions who travel at greater speed in their role to distribute the ball across and down the court often resulting in unintentional contact. Players in the goal positions tend to mark their opposites quite closely because of their restricted movements in their half of the court resulting in multiple but less severe contacts.

*King DA, Hume PA, Cummins C, Clark T, Gissane C, et al. Head impact exposure comparison between male and female amateur rugby league participants measured with an instrumented patch. J Sports Med Ther. 2019; 4: 024-037*

This study undertook a comparison between male and female amateur rugby league player head impact biomechanics. Although females did record some impact magnitudes higher than males in some categories, they recorded more impacts to the side of the head (48% vs. 41%) and had a higher median resultant PRA to the top of the head, whilst males recorded more impacts and had higher magnitudes for all the parameters reported. Female amateur rugby league players recorded the highest PLA(g) on the side of the head (32.0g) but the highest PRA(rad/s<sup>2</sup>) (12,016 rad/s<sup>2</sup>) to the back of the head. Male amateur rugby league players recorded the PLA(g) on the back of the head (52.3g) but the highest PRA(rad/s<sup>2</sup>) (10,876 rad/s<sup>2</sup>) for the front of the head. Although some studies support the possibility that biomechanical differences contribute to greater head accelerations in females, when compared with males, the result of this study does not support this. Other aspects should be included in future studies such as anthropometric aspects of the head and neck and the movement demands and physiological responses of male and female rugby league participants at the same level of participation.

*King DA, Hume PA, Cummins C, Clark T, Gissane C. Does playing away from home influence the number and severity of impacts in amateur rugby union players. Analyses by home/away, won/lost and first/second season halves. Annal Sports Med Res. 2020. 7(3): 1150*

This study undertook a review was undertaken of data obtained from a previous study reporting on head impacts in an amateur senior rugby union team over the 2013 season of competition matches in Wellington, New Zealand. By utilising accelerometer fitted mouthguards in a single premier team throughout the 2013 domestic season of matches there were 20,687 impacts recorded above 10g. Data were extracted and assessed for games played at the club's home venue and played away; games won and lost, and by first and second half of the season. Matches played at away venues, won, and in the first half of the competition season recorded notably more, and had a greater magnitude, impacts to the head. Male rugby players have been reported to have the greatest improvement in strength, flexibility and aerobic fitness during the pre-season, before returning to baseline during the competitive season. This reduction may also occur towards the end of a season due to low training loads, injury rates and high match loads. This may have been the case with the current cohort where the median resultant linear (15.2 g vs. 13.2 g) acceleration recorded was lower in the second half of the season but the median resultant rotational (2,141 rad/s<sup>2</sup> vs. 2,231rad/s<sup>2</sup>) accelerations were higher. Further research is warranted to identify if any correlation exists between the level of fitness of players and the frequency of head impacts that occur.



## Women's rugby union related research

**King DA, Hume PA, Foskett, A & Barnes, MJ. Changes in the stress and recovery of injured versus non-injured amateur domestic women's rugby union team players over a competition season in New Zealand. *NZ J Sports Med.* 2020. 46(2): 74-83**

This study undertook to investigate changes in stress and recovery over a season of training and match participation for injured and non-injured female amateur rugby union players. During 54 training sessions and 12 competition matches over five months there were 79 match related injuries (equating to 330 per 1,000 match hrs. (95% CI: 264.7 to 411.4) injury incidence). Players recorded a higher score in the Physical Recovery scale at the end of the competition season (Month 6) compared with pre-competition, and Month 2 was significantly higher than Month 1. For Month 1 there was a significantly lower Total Stress score compared with the Total Recovery score. Non-injured players recorded a higher General Well-being scale score in Month 2 compared with Month 6 than non-injured players. Injured players recorded a significantly higher Injury scale score in Month 6 compared with pre-competition than non-injured players. Like previous studies in other sports, when the scores for all aspects of the RESTQ-Sport were retrospectively reviewed, the injured female rugby players had lower recovery-related scores and higher stress-related scores than the non-injured female rugby players. The RESTQ-Sport appears to be efficacious for detecting differences in individual rugby players for injury recovery.

**King, D., Hume, P., Clark, T., Foskett, A. & Barnes, M. Incidence of match injuries in an amateur women's rugby union team in New Zealand over two consecutive seasons. *Adv Ortho Sports Med*, 2020. AOASM-129**

This study undertook to determine whether amateur women's rugby union teams in New Zealand need injury prevention support, by providing evidence as to the incidence, causes and severity of injuries that occur during match participation. Using a descriptive epidemiological observational study approach an analysis was undertaken to describe the incidence of match injuries in an amateur women's rugby union team in New Zealand, over two consecutive seasons. Injury burden was calculated for all injuries by: injury region, reported as frequency of injuries by region; number of days lost; and mean number of days lost, with standard deviation. Over the study, 138 injuries were recorded resulting in an injury incidence of 247.0 per 1,000 match-hrs. A total of 57 resulted in a time-loss injury incidence of 102.0 per 1,000 match-hrs. The hooker recorded a significantly lower mean ( $4.1 \pm 2.8$  days) injury burden than the blind-side flanker ( $t_{(6)} = -2.8$ ;  $p = 0.0314$ ), centre ( $t_{(6)} = -2.8$ ;  $p = 0.0313$ ) and fullback ( $t_{(6)} = -2.7$ ;  $p = 0.0351$ ) for total injuries. The principal findings of this study were: (1) total injury incidence was 247.0 per 1,000 match-hrs.; (2) time-lost from rugby due to injuries was 102.0 per 1,000 match-hrs; (3) the lower limb sustained the highest injury incidence with the knee having the greatest proportion of these injuries; (4) the tackle recorded the highest injury rate, and being tackled was associated with a notably higher injury incidence than any other match event; (5) sprains and strains recorded the highest injury incidence; and (6) the lower limb body region recorded the most days lost and had the highest mean days lost per injury.

**King, D., Hume, P.A., Clark, T.N, Foskett, A. & Barnes, M.J. Training injury incidence in an amateur women's rugby team in New Zealand over two consecutive seasons. *J Sci Med Sport*, 2021. 24(6): 544-548**

This study undertook to determine the training injury incidence in amateur women's rugby union in New Zealand over two consecutive seasons. Using a prospective cohort observational study, a total of 69 amateur women's rugby 15s team players were observed. Training exposure and training injury incidence were calculated. The 38 training injuries resulted in a total injury incidence of 11.4 (8.3-15.6) per 1,000 training-hours. There were 12 injuries that resulted in a time-loss injury incidence of 3.6 (95% CI: 2.0-6.3) per 1,000 training-hours. Forwards recorded more total (RR: 1.8 [95% CI: 0.9-3.5];  $p = 0.0516$ ) and time-loss (RR: 2.0 [95% CI: 0.6-6.6];  $p = 0.2482$ ) injuries than Backs. The tackle was the most common injury cause for total (3.0 [95% CI: 1.6-5.6] per 1,000 training-hours.) injuries, but collisions (1.5 [95% CI: 0.6-3.6] per 1,000 training-hours.) with the ground or another person were the most common cause for time-loss injuries. The training injuries occurred most often to the lower limb and during the latter part of training sessions. These injuries were mostly minor in nature resulting in minimal time-loss away from training. The time-loss injury incidence (3.6 per 1,000 training-hours.) for the amateur women's rugby 15s team players was higher than that reported for National (1.2 per 1,000 training-hours.) and Rugby World Cup for women (0.2 to 3.0 per 1,000 training-hours.) competitions. The training injury incidence in amateur women's rugby union in New Zealand was higher than that reported for national and international rugby union injury incidences.



**King, D., Hume, P.A., Clark, T.N. & Pearce, A.J. Use of the King-Devick test for the identification of concussion in an amateur domestic women's rugby union team over two competition seasons in New Zealand. *J Neurol Sci*, 2020. 418(2020):117162**

This study undertook to investigate the use of the King-Devick (K-D) test for sideline assessment of concussive injuries in a New Zealand amateur women's rugby union team. Using a prospective cohort observational approach, all players were K-D tested during pre-season using a tablet (iPad; Apple Inc., Cupertino, CA). Differences in K-D scores and test-retest reliability were calculated for baseline test scores, baseline, and post-injury (concussion) sideline assessment and baseline and post-season testing scores for tests by year and as a combined score. One training-related (0.3 per 1,000 training-hrs.) and nine match-related (16.1 per 1,000 match-hrs.) concussions were recorded. The K-D post-injury (concussion) sideline test score were significantly slower than established baseline ( $-4.4$  [-5.8 to -3.4] s;  $\chi^2_{(1)}=42.2$ ;  $p<0.0001$ ;  $t_{(9)}=-4.0$ ;  $p=0.0029$ ;  $d=-0.8$ ). There was good-to-excellent reliability of the K-D test for baseline (ICC: 0.84 to 0.89), post-injury (concussion) sideline assessment (ICC: 0.82 to 0.97) and post-season evaluation (ICC: 0.79 to 0.83). By utilizing the baseline to post-injury (concussion) assessment comparisons, any player with a post-injury (concussion) assessment slowing of their K-D test time, regardless of whether the player has, or has not had a witnessed insult, should be withheld from any further participation until they are evaluated by a medical professional trained in the management of concussion. This study has provided additional evidence to support the use of the K-D test as a frontline method of assessing concussion with good to excellent reliability of the test for baseline, side-line assessment and post-season evaluation.

**King, D., Hume, P., Clark, T., Hind, K. & Hardaker, N. Concussion reporting and return to play over two years for an amateur women's rugby union team in New Zealand. *Adv Ortho Sports Med*, 2020. AOASM-134**

This study undertook to quantify injury reporting and return to play in an amateur women's rugby union teams in New Zealand. A two-year (2019-2020) retrospective study was undertaken using an online medical history questionnaire for two amateur women's domestic rugby union, club-based teams ( $n=79$ ). The number of concussions reported, concussions medically diagnosed, memory loss, prolonged symptoms ( $>10$  days), returned in the same game and number of concussions reported to the coach in amateur women's rugby union teams in New Zealand were all quantified by player positional group. The combined total of 83 prior concussions for the two seasons resulted in  $2.1 \pm 1.2$  prior concussions per person (i.e.  $\sim 1$  concussion per year). Only two-thirds of previous concussions (68.7%) were reported to team management. A quarter of concussed players reported prolonged ( $>10$  days) symptoms and 7.2% returned to the same game after the concussive event. Within the cohort 16% of previous concussions were reportedly not medically assessed and 32% of the players with a medically diagnosed concussion did not report the concussion to the coach. Players are still returning to the game even though medically diagnosed as having sustained a concussion. There were more concussions sustained by forwards than backs player positions. The player-coach relationship seems to be an important contributing factor for both injury reporting and for providing supportive communication in encouraging safety behaviours. Concussion reporting and safe return to play after concussion diagnosis needs to be improved for amateur women's rugby union in New Zealand.

**King, D., Hume, P.A., Clark, T.N. & Hind, K. Use of the Recovery-Stress Questionnaire – Sport (RESTQ-Sport) and King-Devick test to monitor changes during recovery of concussion in an amateur women's rugby union team. *JSM Physical Med Rehabil*, 2021. 5(1): 1014**

This study undertook to monitor the stress and recovery of players with a concussion in an amateur women's rugby union team over recovery timelines utilising the Recovery-Stress Sport (RESTQ-Sport) questionnaire, King-Devick (K-D) test and Post-Concussion Symptom Scale (PCSS). A prospective observational study was undertaken following an amateur women's domestic rugby union club-based team over two years. A K-D test was conducted for any suspected concussion and confirmed concussions were monitored with the RESTQ-Sport, K-D test and PCSS during the concussion recovery. One training related and nine match related concussions were recorded over the study resulting in a concussion injury rate of 0.3 per 1,000 training hrs and 16.1 per 1,000 match hrs. The post-injury K-D test score was significantly slower than the baseline scores of players with a concussive injury ( $44.2 \pm 7.1$  s vs.  $49.0 \pm 7.3$  s;  $p<0.0001$ ). There was a significant increase in the mean score of the *Fatigue* scale on day-7 when compared with baseline ( $2.36 \pm 0.49$  vs.  $1.64 \pm 0.88$ ;  $p=0.0040$ ). The K-D test recorded a mean slowing (worsening) of reading time of  $-4.7 \pm 1.8$  s increasing to  $-8.8 \pm 2.6$  s on day-3 post injury. Players reported fewer symptoms before the K-D test was equal to, or faster than, the individual players baselines. The RESTQ-Sport and K-D tests were useful tools for the monitoring of individual players stress and recovery and changes of an initial cohort of amateur women's rugby union participants following a mild traumatic brain injury.

## Other sports concussion related research

**Pearce, A., King, D., White, A. & Suter, C. Effects of stricter management guidelines on return-to-play timeframes following concussion in professional Australian Rules football. *Sports Med*, 2021.**

This study undertook to examine the impact of the AFL policy change by asking whether the time to return-to-play after concussion was increased in the 2020 season relative to previous years. Retrospective data on injury and return-to-play were sourced from publicly available tables published on the AFL website. We compared the number of matches missed and the number of days missed in concussed players across 2017 to 2020 inclusive. Analysis of data from 166 concussed players revealed no increase in the number of matches missed in 2020 relative to previous years as would have been expected from an extend recovery protocol. Considering the number of days missed in 2020 relative to 2017-19 we found, paradoxically, that there was an overall reduction in the average time to return-to-play in 2020 (11.2 vs 16.2 days). This study demonstrates that any policy change around concussion management requires ongoing auditing to ensure clearance meets policy objectives and highlights the need for objective measures for return-to-play after concussion.

**Harris, A., Dempsey, A.R., Mackie, K., King, D., Hecimovich, M. & Murphy, M. Do sideline tests of vestibular and oculomotor function accurately diagnose sports-related concussion in adults? A systematic review and meta-analysis. *Sports Med*, 2021.**

This study undertook to examine the diagnostic accuracy of sideline tests of vestibular and oculomotor dysfunction to identify SRC in adults. Electronic databases and gray literature were searched from inception until February 12, 2020. Physically active individuals (>16 years of age) who participated in sports were included. The reference standard for SRC was a combination of clinical signs and symptoms (e.g., the Sport Concussion Assessment Tool [SCAT]), and index tests included any oculomotor assessment tool. The QUADAS tool was used to assess risk of bias, with the credibility of the evidence being rated according to GRADE. A total of 8 studies were included in this review. All included studies used the King-Devick test, with no other measures being identified. Meta-analysis was performed on 4 studies with a summary sensitivity and specificity of 0.77 and 0.82, respectively. The overall credibility of the evidence was rated as very low. Caution must be taken when interpreting these results given the very low credibility of the evidence, and the true summary sensitivity and specificity may substantially differ from the values calculated within this systematic review. Therefore, we recommend that clinicians using the King-Devick test to diagnose SRC in adults do so in conjunction with other tools such as the SCAT.

**Conaghan, C., Daly, E., Pearce, A.J., King, D. & Ryan, L. A systematic review of the effects of educational interventions on knowledge and attitudes towards concussion for people involved in sport – Optimising concussion education based on current literature. *J Sports Sci*, 2021. 39(5): 552-567**

The aim of this systematic review of the literature was to determine the effects of educational interventions on concussion knowledge and attitudes, while providing recommendations for future research in concussion education interventions. Data were extracted from 25 papers following a systematic search of the CINAHL, PubMed/Medline, Science Direct, SPORTDiscus and Web of Science scientific databases. Interventions were designed according to expert opinion and recommendations from previous research, such as knowledge transfer frameworks, the Health Belief Model, Theory of Planned Behaviour or by unknown means. Interventions were presented using PowerPoint presentations, videos, interactive computer modules, tool-kits, games and as guidelines. Interventions designed according to expert opinion increased concussion knowledge during post-intervention testing up to 2 weeks after intervention administration, and occasionally increased attitudes, with both knowledge and attitude improvements tending to return to baseline levels over-time. Interventions designed according to recommendations from previous research tend to increase both knowledge and attitudes with lack of follow-up data to determine long-term effects. Future concussion educational interventions should be designed according to expert opinion and using a knowledge transfer framework. The long-term effects of interventions require more research in order to design more effective educational tools.

**Nguyen, M., King, D. & Pearce, A.J. A reliability and comparative analysis of the new randomized King-Devick test. *J Neuro-Ophthalmol.* 2020. 40(2): 207-212**

The King-Devick (K-D) test is a rapid visual screening tool that can assess underlying brain trauma such as concussion via impairments in saccadic rhythm. A new tablet version of the K-D test using randomized numbers is now available, but reliability for this new version and comparison to the traditional K-D test has not yet been reported. Known for learning effects in the test, the aim of this study was to determine test-retest reliability and to compare performance of the new "randomized" version to the "traditional" K-D test version. We hypothesized that the "traditional" K-D test would show a greater rate of improvement with repeat application, compared with the "randomized" K-D test. Using a cross-sectional, repeated measures design in a healthy university student cohort ( $n = 96$ ; age  $21.6 \pm 2.8$  years; 49 women, 47 men), participants were required to complete the K-D test twice with a one-week break between testing sessions. Participants were randomly assigned into a "traditional" group, where they completed a test-retest of the established K-D protocol, using the same numbers; or the "randomized" group, where they completed test-retest protocol using 2 different sets of numbers. Reliability testing showed a strong intraclass correlation coefficient for both the "traditional" test group (control group; 0.95 [CI: 0.91-0.97]) and the "randomized test group" (0.97 [CI: 0.95-0.98]). However, contrary to our hypothesis, no differences were found between "traditional" and "randomized" groups for baseline (control: 42.5 seconds [CI: 40.2-44.9 s] vs randomized: 41.5 [38.7-44.4],  $p = 0.23$ ) and repeated testing between groups (control: 40.0 seconds [37.9-42.1 s] vs randomized: 39.5 [36.9-42.0],  $p = 0.55$ ), with both groups showing improved times with repeated testing (control: 2.1 seconds [CI: 1.1-3.2 seconds] and randomized: 1.9 seconds CI: [0.9-2.9 seconds],  $p < 0.001$ ). The "randomized" version of the K-D test, using different sets of numbers, demonstrates good reliability that is comparable to the traditional K-D testing protocol that uses the same number sets. However, similar to the "traditional" K-D test, learning effects were also observed in the "randomized" test, suggesting that learning effects are not because of content memorization, but rather familiarity of the test. As a result, although either test format is suitable for sideline concussion screening or return to play decisions, comparison of data should be made to the individual's baseline rather than to normative data sets.

**Pearce, A., Kidgell, D., Frazer, A., King, D., Buckland, M. & Tommerdahl, M. Corticomotor correlates of somatosensory reaction time and variability in individuals with post-concussion symptoms. *Somatosens Mot Res.* 2020. 37(1): 14-21.**

The aim of this study was to quantify the effect of fatigue and related ongoing symptoms on somatosensory and corticomotor pathways using reaction time (RT) testing, and single-pulse and paired-pulse transcranial magnetic stimulation (TMS). Eighty-three participants (nine female, mean age  $37.9 \pm 11.5$  years) were divided into two groups (persistent symptoms versus asymptomatic) following self-report based upon previously published clinical symptom scores. All participants completed somatosensory and visuomotor RT testing, as well as corticomotor excitability and inhibition measurements via TMS. Participants in the persistent symptom group ( $n = 38$ ) reported greater number of previous concussions ( $t = 2.81$ ,  $p = 0.006$ ) and significantly higher levels of fatigue and related symptoms in the asymptomatic group ( $n = 45$ ;  $t = 11.32$ ,  $p < 0.006$ ). Somatosensory RT showed significant slowing and increased variability in the persistent symptoms group ( $p < 0.001$ ); however, no significant differences were observed between groups for visuomotor RTs. Transcranial magnetic stimulation revealed differences between groups for intracortical inhibition at all stimulus intensities and paired pulse measures. The results indicate that somatosensory and corticomotor systems reflect on-going fatigue. From a practical perspective, objective and simplistic measures such as somatosensory and corticomotor measures can be used in the assessment of PPCS and gauging the efficacy of post-concussion rehabilitation programmes.



## Tackle and injury research by Mike Hopkinson's research team

M. Hopkinson, G. Nicholson, D. Weaving, S. Hendricks, A. Fitzpatrick, A. Naylor, C. Robertson, C. Beggs & B. Jones (2021): Rugby league ball carrier injuries: The relative importance of tackle characteristics during the European Super League, *European Journal of Sport Science*, DOI: 10.1080/17461391.2020.1853817

### Abstract

Rugby league carries a high injury incidence with 61% of injuries occurring at tackles. The ball carrier has a higher injury incidence than the defender, therefore understanding mechanisms occurring during injurious tackles are important. Given the dynamic, open nature of tackling, characteristics influencing tackle outcome likely encompass complex networks of dependencies. This study aims to identify important classifying characteristics of the tackle related to ball carrier injurious and non-injurious events in rugby league and identify the characteristics capability to correctly classify those events. Forty-one ball carrier injuries were identified and 205 matched non-injurious tackles were identified as controls. Each case and control were analysed retrospectively through video analysis. Random forest models were built to (1) filter tackle characteristics possessing relative importance for classifying tackles resulting in injurious/non-injurious outcomes and (2) determine sensitivity and specificity of tackle characteristics to classify injurious and non-injurious events. Six characteristics were identified to possess relative importance to classify injurious tackles. This included 'tackler twisted ball carrier's legs when legs were planted on ground', 'the tackler and ball carrier collide heads', 'the tackler used body weight to tackle ball carrier', 'the tackler has obvious control of the ball carrier' 'the tackler was approaching tackle sub-maximally' and 'tackler's arms were below shoulder level, elbows were flexed'. The study identified tackle characteristics that can be modified in attempt to reduce injury. Additional injury data are needed to establish relationship networks of characteristics and analyse specific injuries. Sensitivity and specificity results of the random forest were 0.995 and 0.525.

Mike Hopkinson, Athanassios Bissas, Gareth Nicholson, Clive Beggs, Sean Scantlebury, Sharief Hendricks & Ben Jones (2021): A video analysis framework for the rugby league tackle, *Science and Medicine in Football*, DOI: 10.1080/24733938.2021.1898667

SCIENCE AND MEDICINE IN FOOTBALL  
<https://doi.org/10.1080/24733938.2021.1898667>



OPEN ACCESS

## A video analysis framework for the rugby league tackle

Mike Hopkinson <sup>a</sup>, Athanassios Bissas <sup>b</sup>, Gareth Nicholson <sup>a</sup>, Clive Beggs <sup>a</sup>, Sean Scantlebury<sup>a,c</sup>, Sharief Hendricks <sup>a,d</sup> and Ben Jones <sup>a,c,d,e,f</sup>

<sup>a</sup>Carnegie Applied Rugby Research (CARR) Centre, Carnegie School of Sport, Leeds Beckett University, Leeds UK; <sup>b</sup>Athletics Biomechanics, Leeds, UK; <sup>c</sup>England Performance Unit, The Rugby Football League, Leeds, UK; <sup>d</sup>Division of Exercise Science and Sports Medicine, Department of Human Biology, Faculty of Health Sciences, The University of Cape Town, Cape Town, South Africa; <sup>e</sup>Leeds Rhinos Rugby League Club, Leeds, UK; <sup>f</sup>School of Science and Technology, University of New England, Armidale, NSW, Australia

### ABSTRACT

Rugby league tackle video analysis research typically uses technical criteria from coaching cues or tackle variables from rugby union. As such, content validity and relevance could be questioned. A video analysis framework that establishes appropriate variables for rugby league is therefore required. The study aimed to adopt a 5-stage process to establish a video analysis framework for the rugby league tackle, which was content valid, relevant and reliable.

The 5-stage process included 1) creation of draft video analysis framework, using available rugby tackle research, 2) expert group recruitment and critique, 3) refinement of framework to establish content validity, 4) response process validity task and agreement within expert group, 5) intra- and inter-reliability testing using Kappa statistics.

The agreed framework comprised six phases including; tackle event, defensive start point, pre-contact, initial contact, post-contact and play-the-ball. Within the identified phases, 63 variables were established. The intra- and inter-reliability testing resulted in strong agreement within all phases.

The video analysis framework can be used in rugby league tackle research, categorising complex tackle events, such as injurious or optimal tackles, improving both player welfare and performance. The application of the framework to future rugby league research will increase coherence and usefulness of research findings.




### ARTICLE HISTORY

Accepted 25 February 2021

### KEYWORDS

Rugby league; tackle; variables; video analysis; injury; performance

**Table 1.** Overview of tackle phase variables, descriptors and definitions.

TACKLE PHASES	
AGREED PHASE	DEFINITIONS
Tackle Event	Variables which describe the scenario of the occurring tackle.
Defensive start point	Variables which describe where the tacklers were positioned between the end of the previous play the ball to initial contact.
Pre-contact phase	Variables which occur from 0.5 seconds before contact to initial contact for both tackler(s) and ball carrier (Fuller et al., 2010)
 <p>0.5 seconds before contact      Tackler 1 initial contact      Tackler 2 initial contact</p>	
Initial contact phase	Variables which occur immediately at the first point of contact between ball carrier and tackler(s).
Post-contact phase	Variables which occur between initial contact and the tackle end, which is either by grounding of the tackler or called by the referee.
 <p>Tackler 1 initial contact      Tackler 2 initial contact      Tackle end</p>	
Play the ball phase	Variables which occur from when the tackle ends to when the ball carrier has played the ball under their foot.
 <p>Tackle end      Play the ball</p>	

**James Brown update**[jamesbrown06@gmail.com](mailto:jamesbrown06@gmail.com)

Congratulations to Emily Skelding who passed her Masters' thesis. James will provide an update for the 2022 RCRG eMagazine.

**Sayumi Iwamoto update**岩本紗由美 [siwamoto@toyo.jp](mailto:siwamoto@toyo.jp)

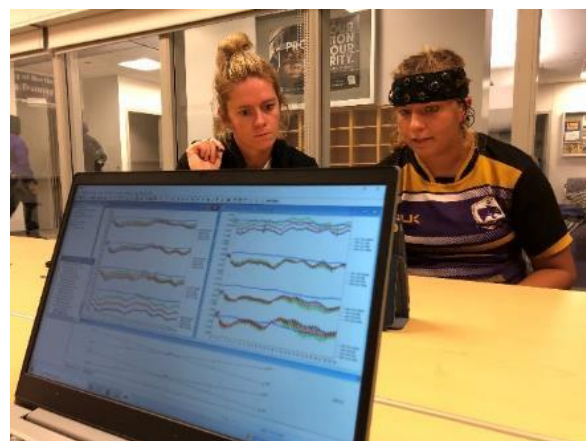
Currently, working on the physical measurement of top-level players in Japan as a joint project with the Japan Rugby Football Union 15-member Japan National Team Strength & Conditioning Division. This project is part of a physical conditioning project for training young people to aim for further evolution as a Japanese national team in the next World Cup and beyond, and in particular, grasp the current state of physique including lean body mass of rugby players. At the same time, the purpose is to clarify the characteristics of each position.



## King-Devick and functional near-infrared spectroscopy project update by Associate Professor Mark Hecimovich

Athletic Training, University of Northern Iowa, 003C Human Performance Center, Cedar Falls, IA 50614-0244, Phone: 319.273.6477, [mark.hecimovich@uni.edu](mailto:mark.hecimovich@uni.edu)

Dr Mark Hecimovich and Dr Doug King are conducting a rugby-based research project with the use of the King-Devick (KD) and functional near-infrared spectroscopy (fNIRS), an optical brain monitoring technique which uses near-infrared spectroscopy for the purpose of functional neuroimaging. Using fNIRS, brain activity is measured by using near-infrared light to estimate cortical hemodynamic activity which occur in response to neural activity. fNIRS is one of the most common non-invasive neuroimaging techniques which can be used in portable contexts. The KD and fNIRS was administered at the beginning of the season to obtain baseline measurements and after each match on those participants who sustain a concussion and 5 to 7 other non-concussed participants. Additionally, their study includes the 3M™ Bair Hugger™ Temperature Monitoring System, a non-invasive, accurate core temperature monitoring system that continuously measures patient temperature with a single-use sensor, providing standardization and a consistent temperature monitoring method throughout the measurement process. This device will be used on all participants prior to a match and 5 to 7 participants post-match, including any participant who sustained a potential concussion.



## Francesco Sella's study on female rugby sevens

Francesco S. Sella<sup>1</sup>, Christopher M. Beaven<sup>1</sup>, Stacy T. Sims<sup>1,2,3</sup>, Daniel T. McMaster<sup>1</sup>, Nicholas D. Gill<sup>1,4</sup>, Kim Hébert-Losier<sup>1</sup> The effects of menstrual cycle phase on physical performance in female rugby athletes: A case-study. *The Journal of Sport and Exercise Science*, Vol. 5, Issue 5, 310-320 (2021)

<sup>1</sup> Te Huataki Waiora School of Health, University of Waikato Adams Centre for High Performance, Mount Maunganui, New Zealand; <sup>2</sup> Sports Performance Research Institute New Zealand (SPRINZ), AUT University, Auckland, New Zealand; <sup>3</sup> High Performance Sport New Zealand (HPSNZ), Auckland, New Zealand; <sup>4</sup> New Zealand Rugby, Wellington, New Zealand

### ABSTRACT

*Limited research exists on the effects of menstrual phase on athletic performance in team sport athletes. In this case-study we investigated the potential effect of menstrual cycle phase on several physical qualities in rugby athletes. Four eumenorrhoeic female rugby athletes completed a battery of physical tests weekly for 5-9 weeks, including 10-m sprint, countermovement (CMJ) and drop (DJ) jumps, isometric mid-thigh pull (IMTP), and Bronco. Concurrently, athletes tracked their menstrual cycle with a smartphone application (FitWoman™). To investigate differences in physical performance between phases, data were allocated into four different menstrual phases at the date of each weekly test. A mixed linear model was created for each physical quality of interest. Mean changes between phases were estimated using magnitude-based inferences with 90% confidence intervals. Individual differences between the average score for each menstrual phase with the value predicted by the trend of the other three phases were also assessed. At a group-level, possible greater performances were observed in the CMJ during the late luteal phase compared with menstruation, in the DJ during late luteal compared with luteal, and in the IMTP during late luteal compared with follicular to ovulation ( $\Delta\%$  = 4.9-7.0%). A variety of responses were observed between individuals for all the tests conducted. Understanding and accounting for individual responses during the menstrual cycle will likely be beneficial to training prescription and interpreting performance monitoring results.*

## Dr. Victor Lopez Jr's teams work on U.S. Rugby 7's Rugby Project for Injury Surveillance



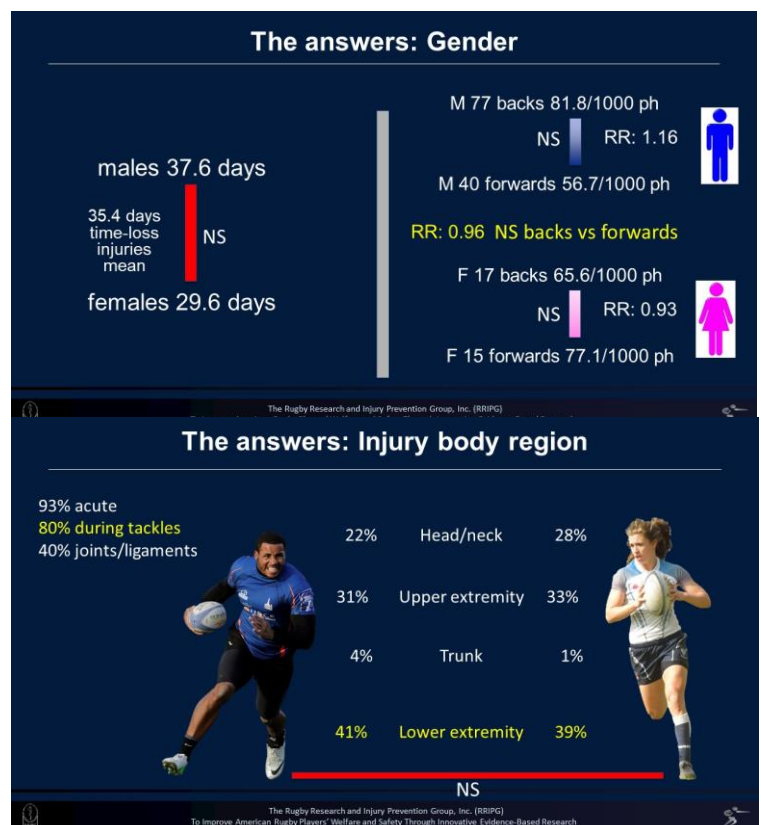
Attending major tournaments/series and championships across the U.S. and expanding across North America. The RRIPGs Rugby Injury & Safety Evaluation (RISE) methodology dataset, has the ability to enable analyses of the many factors of U.S. Rugby-7s in detail. They have reached a major milestone of 10 years of data, this 2021. The impact of this data, will answer questions whether injuries among developing markets and the nurturing of their youth athletes are exclusive to North America or are they symptomatic of developing rugby markets in general? The results of this study provide much needed data on Rugby-7s in emerging countries, such as the U.S. This is our most recent analysis capable of yielding an impact in the clinical literature on Rugby-7s.

Lopez V Jr, Ma R, **Weinstein MG**, Hume PA, **Cantu RC**, Victoria C, **Queler SC**, **Webb KJA**, Allen AA. United States Under-19 Rugby-7s: Incidence and Nature of Match Injuries During a 5-year Epidemiological Study. *Sports Med Open*. 2020 Aug 27;6(1):41. doi: 10.1186/s40798-020-00261-y. PMID: 32852666. <https://sportsmedicine-open.springeropen.com/articles/10.1186/s40798-020-00261-y>

[020-00261-y](https://sportsmedicine-open.springeropen.com/articles/10.1186/s40798-020-00261-y)

**Background:** There is a lack of injury data for the new Olympic sport of Rugby-7s, particularly for involved youth. **Objective:** To determine injury rates and characteristics for players participating in American Rugby-7s U19 (under 19 years of age) tournaments. **Methods:** Rugby Injury Survey & Evaluation report methodology, at 24 US Rugby-7s U19 tournaments over 30 days(2010-2014). Tournament medical-attention and time-loss injuries were recorded. **Results:** as summarized in the slides.

**Conclusions:** The match injury incidence of 82.4/1000ph for U19 participants in Rugby-7s was like adult participants in Rugby-7s. Recurrent match injury risk was high at 23%. Females sustained a greater proportion of time-loss joint/ligament and muscle tendon injuries than males. The first three matches of a tournament day result in the most injuries.



Singh SP, **Lopez V Jr.**, Ma R, Weinstein MG, Bonnani S, Ogbemudia RO, **Allen AA**. Medical Costs of Player Injuries in U.S. Rugby-7's Regional Tournaments: A 5 Year Analysis. *European College of Sports Sciences*. October 2020. <http://ecss-congress.eu/2020> . Full presentation available at: [RRIPG Channel](#)



Borthwick KG, **Victoria C**, Marcano ED, Moir MP, Singh SP, Ma R, **Allen AA**, **Lopez V Jr.** Injury Profile in U.S. Men's University Rugby-7's Players: A Six-Year Analysis. *Medicine & Science in Sports & Exercise*. June 2021. 53. 206-206. 10.1249/01.mss.0000761460.00615.e1. Full presentation available at: [RRIPG Channel](#)



Steinhardt School of Culture, Education, and Human Development







## Rugby Research & Injury Prevention Group

Dr Victor Lopez Jr is Director, [Rugby Research and Injury Prevention Group, Inc.](#), affiliated with [Hospital for Special Surgery](#), NY, NY, USA

Victor's group hopes everyone is well through these turbulent times. Their group have been working virtually over these past 2 ½ years. Their group has attended as many major sports science and medicine conferences possible around the globe over 2019-2021, promoting their efforts to understand the injury burden in U.S. Rugby-7s. This has been through the efforts of their collaborations with Auckland University of Technology, SPRINZ, Emerson Hospital in Connecticut, Missouri Orthopedic Institute, New York University and recently developing relationships with Boston University and Massachusetts General Hospital. This has been through their generous sponsors the National Operating Committee on Standards for Athletic Equipment ([www.nocsa.org](http://www.nocsa.org)), HSS Institute for Sports Medicine Research (<https://www.hss.edu/>). As well as individual private sponsors Paromed Podiatry/Orthotics AUS/NZ (<https://www.paromed.com.au/>).

Events & Professional Conference Attendance since the last update in 2019:

- Kansas City Dept Public Health Intervention Conference (**2019 KC, MO, Dr Som P Singh, MD**)
- ASICS Sports Medicine Australia (**2019 Symposium Chair & 2-topics Podium, Twin Waters, Brisbane, AUS**)
- American College Sports Medicine (**2020 2-Case Studies, Virtual, USA**)
- European College of Sport Sciences (ECSS) (**2020 3-topics, Sevilla, Virtual**)
- **American College Sports Medicine** (2021 3-Topics, Virtual, USA)
- Women in Sport and Exercise, **Worcester, London, UK (2021 2-topics via Twitter Virtually)**
- USARugby National Club Championships, Seattle WA (**2021, SP Singh MD (2022) & KG Borthwick MD (2025)**)

Awards Shortlisted & Nominations:

- **2021 ACSM Greater NY Meeting** - Presidential Cup (3- individual topics) - Borthwick KG et al., Smith TA et al, Singh SP et al.
- 2019 ASICS Sports Medicine Australia (**1-topic**) Lopez et al. **Sports Injury Prevention & Clinical Sports Medicine**



**2021 Tri-State Rugby-7s Tournament & 2021 RRIPG Interns:** Khalil JA Webb BS (Arizona State), Owen Kuchinad (Stuyvesant HS), Eric-Jon Sero, BS (Stony Brook Univ., NY), Freedom Salas BS (Pennsylvania State Univ. 2023), Samuel Y Haleem (Arkansas School of Medicine, DO 2023) Lauren Samuels (Berkley University, Calif., BS 2022), Jasmin Strong MS, BS (University Southern California 2022/Cornell University) and Dr. Lopez. Hosted by Danbury RFC (L to R).



**2019 ASICS Sports Medicine Australia Annual Conference, Twin Waters, Brisbane, AUS.**

Lopez et al. Shortlisted for SMA Sports Injury Prevention & Clinical Sports Medicine Award (Dr Lopez won this in 2017).



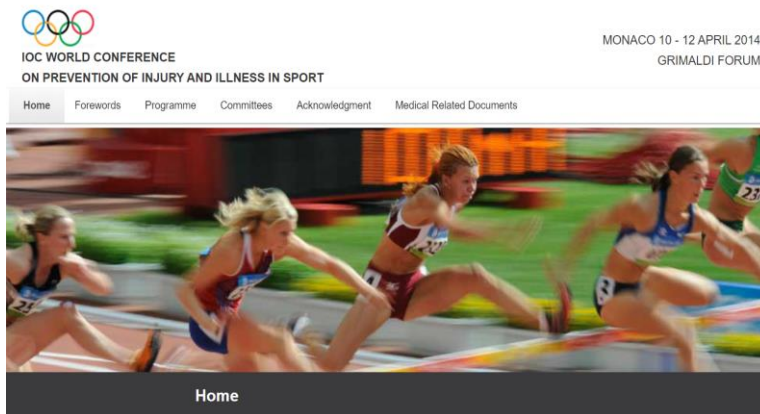
**2019 ASICS Sports Medicine Australia Annual Conference, Twin Waters, Brisbane, AUS.** Dr. Richard Ma, MD (Co-Director, RRIPG), Professor Patria Hume, Dr. Victor Lopez Jr DO, Professor Matthew Attwood (Cardiff Metropolitan University) -not in picture & Daniel Rodgers MSATC (San Diego State University), for our SMA Symposium on [rugby union injury prevention for both 7s and 15s](#). Chairperson: Dr V Lopez, Jr.



**2021 USA Rugby National Club Championships, Seattle WA:** In Attendance Danielle Baker LAT ATC, Dr. Kiera G. Borthwick MD (2025), Dr. Som P. Singh MD (2023), Drew Pennington PT, MPT, OCS, SCS, Ms Sameera Sheikh BS (2022).



## IOC WORLD CONFERENCE ON PREVENTION OF INJURY & ILLNESS IN SPORT: MONACO, 25 - 27 NOVEMBER 2021



**3<sup>rd</sup> time's a charm:** Dr. Lopez's RRIPG/HSS and their affiliations, since their establishment in 2009, are fortunate to have contributed to the growth of rugby in North America. The USA has seen major growth with the sport, RRIPG/HSS is very happy to have contributed by its pioneering research and sports medicine care. Dr Lopez has contributed bringing [Major League Rugby's](#) NY franchise team, [Rugby United New York](#) to HSS to add to their Major League portfolio names: Giants, Knicks, Nets & Red bulls to name a few. The unique area of Sports Science and Medicine has been at the forefront for RRIPG/HSS. They have been acknowledged by many sports institutions and governing bodies. Therefore, they were honoured to present their preliminary Rugby-7s shoulder injury data, at the [IOC conference in 2014](#) with [Dr. Lyndon B. Gross MD PhD](#), Chesterfield/St Louis, MO, on Shoulder injuries in Tae kwon do, Judo & Rugby. Then at the [IOC Conference in 2017](#), Dr. Lopez and [Dr. Shen-Ying \(Richard\) Ma, MD](#), [Missouri Orthopaedic Institute, Columbia, MO](#), where they had multiple thematic presentations on Rugby-7s concussion and women's injuries.



In 2021 Dr Lopez and Dr. Ma, (LEFT: HSBC Las Vegas 2012 to RIGHT IOC Monaco 2017) will be presenting 2 thematic talks and jointly presenting the IOC Workshop of: [RUGBY-7S IS FAST, BUT ARE WE RUNNING AND ABOUT TO KNOCK-ON! EVIDENCE-BASED RUGBY-7S INJURY PREVENTION CONCEPTS](#). He hopes to provide insight on the growth within a developing market that could be modelled in emerging National Olympic Committees Rugby-7s programmes. Professor Patria Hume has been pinnacle in guiding RRIPG and their work internationally. She was initially accepted to co-present with Dr Lopez at the 2020 IOC Conference but due to it being postponed due to covid, unfortunately will not attend. He is happy that Dr Ma will help present the work they have been doing since 2009. Dr. Ma is a Clinician Scientist, recipient of the AOA/JOA Traveling Fellowship. Dr. Ma is currently the Chief of the Division of Sports Medicine, and the Gregory L. and Ann L. Hummel Distinguished Professor in Orthopaedic Surgery, at the University of Missouri. He has humbly agreed to take Professor Hume's place in co-presenting their workshop. Dr. Ma has been an integral part of their group since, 2009, and his time as a Sports Medicine and Shoulder Surgery Fellow at Hospital for Special Surgery in NYC under Dr. Scott Rodeo and Dr. Answorth Allen.

## DR. VICTOR LOPEZ JR. IS HONORED TO HAVE US RUGBY-7S DATA PRESENTED FOR THIRD IOC CONFERENCE:

The build-up is clear, guided by the work seen in 2003, while at Ulleval Sykhus and the Oslo Sports Trauma Research Centre, Oslo, Norway, his early exposure was under the tutelage of pioneers, which has continued under Professor Hume and their collaborations since 2014 at AUT/SPRINZ. He was humbled to be the [2014 AOSSM speaker on Rugby-7s](#) in America, and interviewed by [Orthopaedics Today](#). We jump ahead and note in 2018, he became the 2018 ACSM Clinical Tutorial Lecturer for rugby: [Evidence-Based Injury Trends and Risk in a Growing U.S. Amateur Collision Sport: The North American RISE Rugby Registry and Rugby-7s](#). He was then honoured to win in 2017 two awards one from ACSM and then SMA in [two hemispheres on the two formats of rugby \(7s & 15s\)](#). This was when he won down under the [ASICS Sports Medicine Australia \(SMA\) Conference -the BEST NEW INVESTIGATOR IN SPORTS INJURY PREVENTION & CLINICAL SPORTS MEDICINE](#), with his work on U.S. Rugby-7s. As the sport grows in North America, stakeholders are still challenged with the expansion of the sport globally. So he put together an international Panel to co-present alongside with Professor Hume and Dr Lopez, who Session Chaired the Sports Medicine Australia, ["Rugby Union Injury Prevention Programmes: Running into the tryzone for 7s and 15s."](#) Which brings us to the 2021 IOC conference.

This November he is planned to present Nov 25, 2021 at 15:30PM, Nov 26, 2021 - 15:00PM, & Nov 27, 2021 11:30AM. The importance is clear, to aid in the injury prevention model for translation of player welfare. He thanks all the teams, players and administrators, tournament directors who have helped him and tirelessly promote the sport for the love of it!



2016 IOC World Conference: Dr Lopez honoured to be with his mentors Lars Engebretsen, MD PhD Head of Medical Sciences, the International Olympic Committee and Roald Bahr, MD PhD, Chair, IOC Scientific Committee, from Ulleval Hospital, and co-chairs of the Oslo Sports Trauma Research Center, Oslo, Norway. March 18, 2017, Monaco.

Our skilled staff would like to thank all the players that contributed in the competitions, clinics and combines; as well as all the dedicated staff for all the events, to develop the American playing population, it was my

honour to be involved and wish the current national candidate players the best of luck in this upcoming Rugby-7s developmental cycle. Wishing the teams for the Sep 8, 2023 – Sat, Oct 28, 2023 RWC the best of luck! Go USA!

Thanks to the multiple tournament directors/administrators across all the USAR Territorial Unions and North American RAN 1 (formerly the North American Caribbean Rugby Association) and team officers for their tireless efforts of promoting rugby in the U.S. and executing the events for the development of players, teams and enjoyment of all.

The RRIPG THANK, [Dr. Answorth A. Allen](#), concussion expert [Dr. Robert C Cantu](#), and Professor Patria Hume [AUT & SPRINZ](#), & Sponsors [Hospital for Special Surgery](#) a US Olympic Committee Medical Treatment Center and the [National Operating Committee on Standards for Athletic Equipment](#), including [United World Sports](#) and [USA Rugby](#) for attendance at their events.



# AUT TRAUMATIC BRAIN INJURY NETWORK UPDATE

## Professor Alice Theadom - Director of TBIN

At the New Zealand GP conference Alice outlined the development of the Brain Injury Screening Tool (BIST). Selected slides are included in this emagazine. For further information see [TBI Network - TBI Network - AUT](#)



**AUT TRAUMATIC BRAIN INJURY NETWORK**

**AUT**

About us Our research Our expertise Support and resources

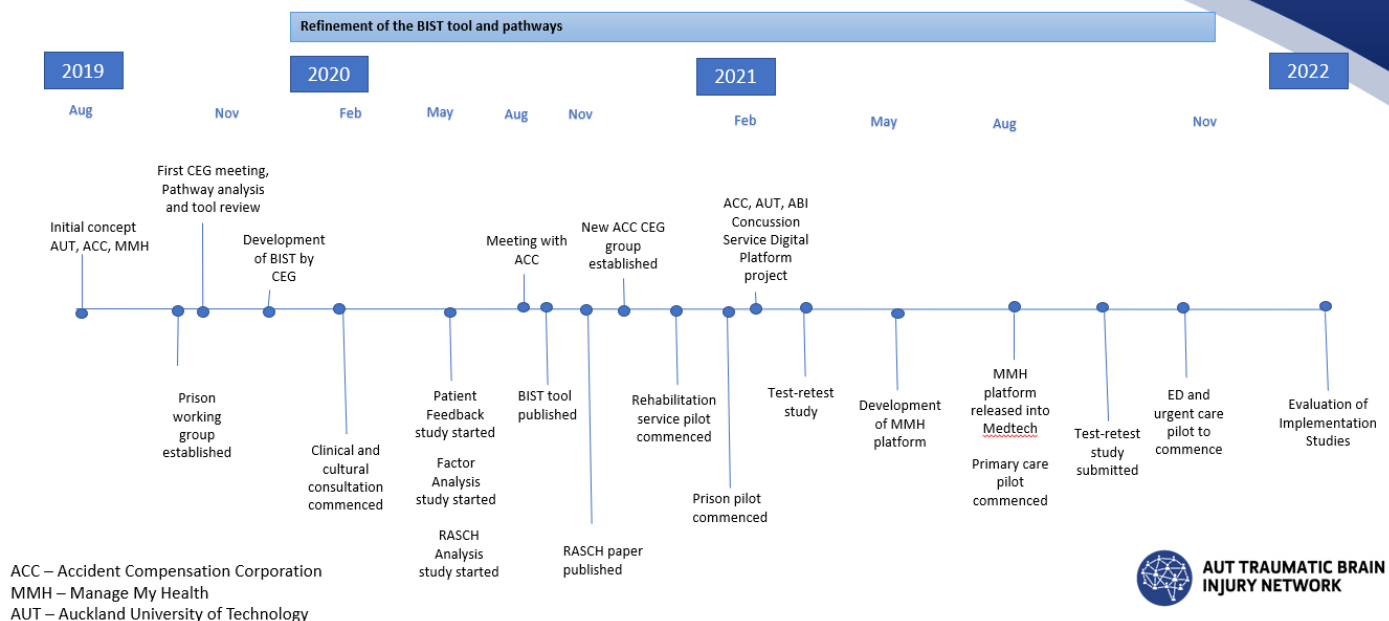


## Improving recovery for people experiencing traumatic brain injuries

Nearly 1/3 of people have experienced at least one traumatic brain injury by age 25. Almost half go on to experience long-term problems. The TBI Network aims to support better health and wellbeing for people with traumatic brain injuries by uniting people, services and research to discover how to optimise recovery.



## Development of the BIST mild TBI pathways



**AUT TRAUMATIC BRAIN INJURY NETWORK**





**AUT TRAUMATIC BRAIN  
INJURY NETWORK**



RUTHERFORD  
DISCOVERY FELLOWSHIPS



WSM

WELLINGTON  
SPORTS MED



## A brief assessment tool to facilitate assessment and management of mild traumatic brain injury/concussion

Developed by Alice Theadom, Natalie Hardaker, Penelope Day, Kris Fernando, Katherine Forch, Kevin Henshall, Doug King, Mark Fulcher, Renata Gottgroy, Sam Jewell, Stephen Kara, Patria Hume.

## What we now know about mild TBI from large scale epidemiological studies

### Not everyone recovers as quickly as we used to think.

#### At 12 months

- 53% of mTBI participants reported functional limitations (Nelson et al, 2019)
- Nearly half of participants (47.9%) experienced  $\geq 4$  post-concussion symptoms (Theadom et al, 2016)
- 40.3% of patients had significantly reduced satisfaction With Life scores (McMahon et al, 2014)

#### At 4 years

- Compared to controls – untreated mild TBI have significantly higher;
  - Cognitive symptoms ( $F = 19.90$ ,  $p = <0.01$ )
  - Poorer productivity ( $F = 199.07$ ,  $p = <0.01$ )
  - Social relations ( $F = 13.93$ ,  $p = <0.01$ )
  - community engagement ( $F = 364.69$ ,  $p = <0.01$ ) (Theadom et al, 2018)

#### Recovery trajectories are not always linear

- Symptoms increased significantly from 3 to 6 months (McMahon et al, 2014)



## Ten key gaps identified:

1. Public awareness of need to seek medical attention.
2. MTBI rarely occurs in isolation
3. Variation in GP confidence in managing concussion
4. Uncertainty who to send to which service and which services are there!
5. Process of making a referral is confusing for practitioners
6. Recovery advice is inconsistent
7. Long delays between initial medical presentation and first appointment at concussion service.
8. Need for routine follow up to facilitate referral if needed
9. No feedback loop following a referral
10. No routine evaluation of effectiveness of services

Need to work across the whole sector to develop a coordinated, consistent approach



## An evidence-based tool to help brain injury assessment and management

- Designed as a guide for use on initial medical presentation
- For use where there is a suspected brain injury (or concussion) aged  $\geq 18$  years.
- The BIST takes about 6 minutes to complete.
- Identifies patients who are at low, medium or high risk of poor recovery
- Encourages use of additional assessments/questioning based on responses
  - e.g. if dizzy conduct balance assessment
- Allows for flexibility


**AUT TRAUMATIC BRAIN INJURY NETWORK**

### Brain Injury Screening Tool (BIST)

A guide to traumatic brain injury assessment

The BIST was developed to be a brief tool for use on initial presentation after injury to guide health care pathway decision making and to monitor symptoms and recovery over time. Its purpose is to help guide the clinical assessment conversation by operationalising current international best practice guidelines.<sup>1</sup>

The BIST has been developed for health professionals working across primary and secondary health care and for sports and other contexts where traumatic brain injuries (TBI) can occur.

The BIST can facilitate clinical decision making through identification of people who are at low, medium or high risk of longer-term difficulties.

This tool should be used in addition to clinical judgment and other assessments such as the Vestibular/Oculomotor Motor Screening (VOMS), King-Devick or the Romberg's test. Additional questioning to add to the clinical picture is encouraged.

The first 9 questions in the BIST are designed to assist if there are clinical indicators that the person is at high risk of complications or poor recovery and requires hospital evaluation. The 15-item symptom scale is designed to assist in identifying patients at moderate risk of poor recovery who may benefit from early specialist treatment and low risk patients who are likely to recover well, supported within primary care.

Date of Injury:  Time of Injury:  Date of Consultation:

Age:  Gender/Sex:

1. If over 65 years, security assessment or being alone consider referral to the Emergency Department.

Ethnicity:  If your answer is OTHER please specify:



**AUT TRAUMATIC BRAIN INJURY NETWORK**

## About the BIST

- Follows a traditional clinical consultation
- Questions identify evidence based- clinical indicators for poor recovery
- 16-item symptom checklist
- Overall impact of injury item
- On first appointment indicates those at high risk - who may need hospital evaluation
- Follow up at 7-10 days (symptom scale and impact item)

If not recovered - responses used to identify those at;

- Moderate risk - who may need specialist or rehabilitation referral
- Low risk - who can be managed in primary care

Patient Details | **Symptom Score** | Patient History | Provider Details

Name: MICKEY MOUSE | DOB: 01/01/1975 | Symptoms: 9/10 | Severity: 90/100

Compared with before the accident, how much do you now experience any of the following on a scale of 0-10?

I have trouble concentrating

0 1-2 3-4 5-6 7-8 9-10

Not at all A little/Mild Quite a lot/Moderate A lot/Severe

0 1 2 3 4 5 6 7 8 9 10

Please select the number that most closely fits for you.

< PREVIOUS NEXT >

Question: 9/10

Injuries to the brain can affect how a person feels, behaves, thinks and how able they are to do everyday tasks. On a scale of 0 to 100, where 0 means that you do not feel the injury has had any impact on you at all and 100 means you feel that injury stops you from doing anything, how much do you feel your injury is impacting on you at this point in time?



## Benefits of using the BIST



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

# "1000 REASONS FOR HOPE" UPDATE

Dr Chris Nowinski and Dr Robert Cantu – Brain Legacy

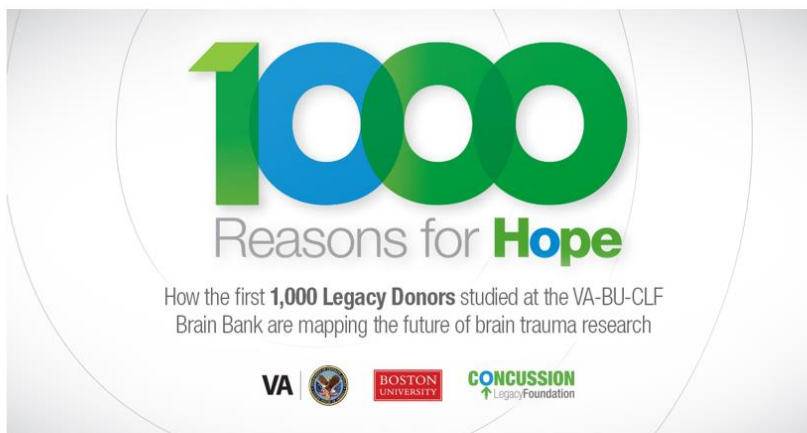


ConcussionFoundation.org

Dr Chris Nowinski <[nowinski@concussionfoundation.org](mailto:nowinski@concussionfoundation.org)> and Dr Robert Cantu with colleagues provided the 1,000 Reasons for Hope report on how the first donors of their brains at the VA-BU-CLF Brain Bank are mapping the future of brain trauma research. These slides have been kindly provided by Chris and the team as an overview of the programme. These slides are available to RCRG members from the Global Rugby Health Research Group Team site. If you would like access to this site please contact [patria.hume@aut.ac.nz](mailto:patria.hume@aut.ac.nz).



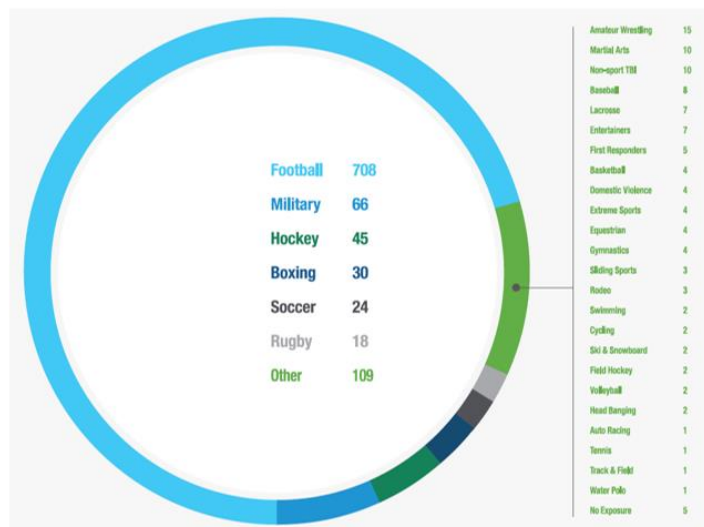
## 1,000 Reasons for Hope



ConcussionFoundation.org

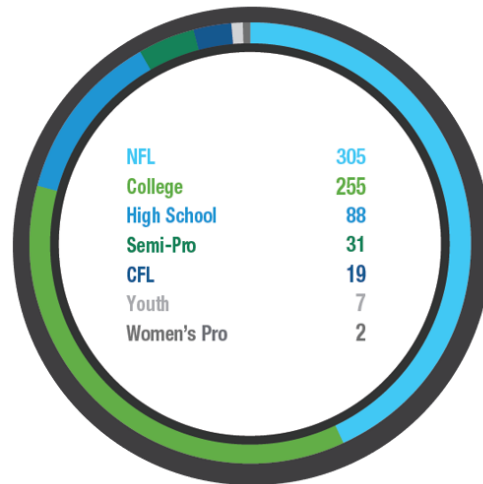


## Primary Exposure of Donors

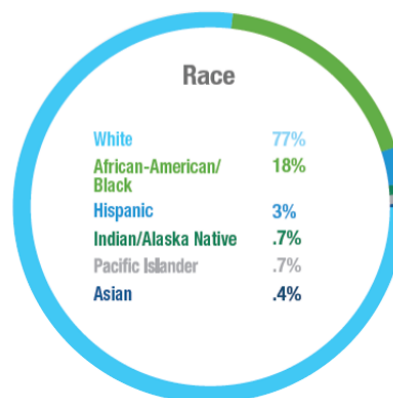
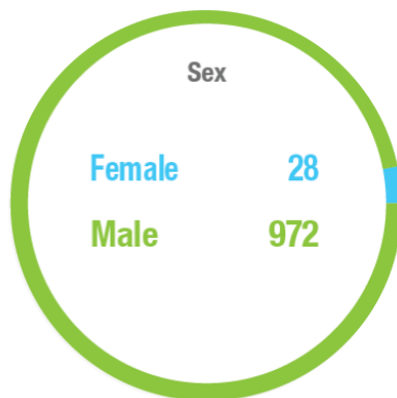




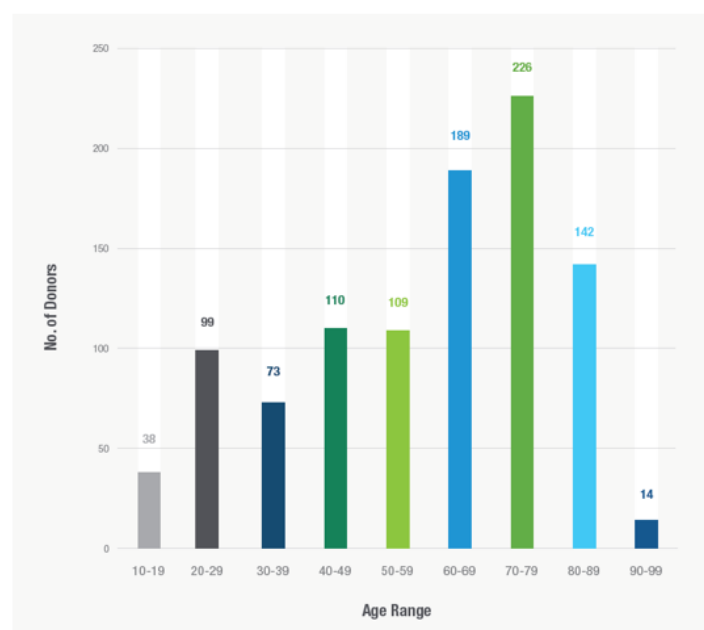
## Highest level of football played by donors



## Sex and race of donors



## Decade of death of donors







## 10 landmark studies

# 10 Landmark Studies

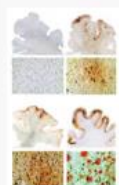
Since 2008, the VA-BU-CLF Brain Bank has published more than 100 game-changing studies. Here, we spotlight 10 breakthrough studies published by Brain Bank researchers since 2009.

2009

**Chronic Traumatic Encephalopathy in Athletes: Progressive Tauopathy After Repetitive Head Injury**

**Journal of Neuropathology & Experimental Neurology**

We review 48 cases of neuropathologically verified CTE recorded in the literature and document the detailed findings of CTE in three professional athletes (one football player and two boxers).

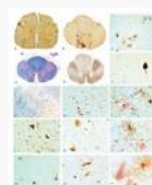


2010

**TDP-43 proteinopathy and motor neuron disease in chronic traumatic encephalopathy**

**Journal of Neuropathology & Experimental Neurology**

In some individuals with CTE, the TDP-43 proteinopathy extends to involve the spinal cord and is associated with motor neuron disease. This was the first pathological evidence that repetitive head trauma experienced in collision sports might be associated with the development of a motor neuron disease.

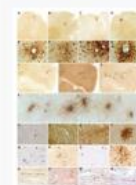


2012

**Chronic Traumatic Encephalopathy in Blast-Exposed Military Veterans and a Blast Neurotrauma Mouse Model**

**Science Translational Medicine**

These results identify common pathogenic determinants leading to CTE in blast-exposed military Veterans and head-injured athletes and additionally provide mechanistic evidence linking blast exposure to persistent impairments in neurophysiological function, learning, and memory.

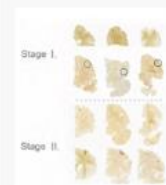


2013

**The spectrum of disease in chronic traumatic encephalopathy**

**Brain**

The frequent association of chronic traumatic encephalopathy with other neurodegenerative disorders suggests that repetitive brain trauma and hyperphosphorylated tau protein deposition promote the accumulation of other abnormally aggregated proteins including TAR DNA-binding protein 43, amyloid beta protein and alpha-synuclein.



## 10 landmark studies

2016

**Tau prions from Alzheimer's disease and chronic traumatic encephalopathy propagate in cultured cells**

**Proceedings of the National Academy of Sciences**

The progressive nature of neurodegenerative diseases is due to the spread of prions, misfolded infectious proteins, in the brain. This study established that CTE prions are distinct from prions in other tauopathies such as Pick's disease and progressive supranuclear palsy.

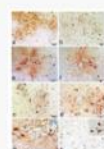


2016

**The first NINDS/NIBIB consensus meeting to define neuropathological criteria for the diagnosis of chronic traumatic encephalopathy**

**Acta Neuropathologica**

The first consensus criteria endorsed by the National Institutes of Health for the pathological diagnosis of CTE was made possible by the VA-BU-CLF Brain Bank. In 2015, eminent neuropathologists from around the world, along with observers from the National Institute of Neurological Disorders and Stroke and the National Institute of Biomedical Imaging and Bioengineering, gathered at Boston University School of Medicine to review cases at the Brain Bank.

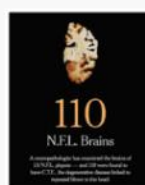


2017

**Clinicopathological Evaluation of Chronic Traumatic Encephalopathy in Players of American Football**

**Journal of the American Medical Association**

Among 202 deceased former football players, CTE was neuropathologically diagnosed in 177 players (87%); including 0 of 2 pre-high school (21%), 48 of 53 college (91%), 9 of 14 semiprofessional (64%), 7 of 8 Canadian Football League (88%), and 110 of 111 National Football League (99%) players.

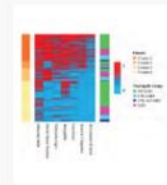


2018

**Lewy Body Pathology and Chronic Traumatic Encephalopathy Associated with Contact Sports**

**Journal of Neuropathology and Experimental Neurology**

Contact sports participation may increase risk of developing neocortical Lewy Body Disease, and increased Lewy Body Disease frequency may partially explain extrapyramidal motor symptoms sometimes observed in CTE.

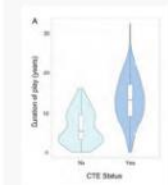


2019

**Duration of American Football Play and Chronic Traumatic Encephalopathy**

**Annals of Neurology**

A study of 266 football players, of which 223 had CTE, explored risk factors affecting CTE status and severity. The study revealed that each year of tackle football participation increases the odds of developing CTE by 30 percent and increases the odds of having severe CTE by 14 percent. The findings inspired CLF's award-winning "Tackle Can Wait" campaign.

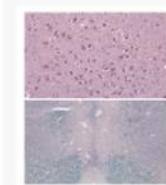


2020

**Association of probable REM sleep behavior disorder with pathology and years of contact sports play in chronic traumatic encephalopathy**

**Acta Neuropathologica**

Probable REM Behavior Disorder (pRBD) in CTE is associated with increased years of contact sports participation and may be attributable to Lewy body and brainstem tau pathologies. Athletes with CTE were 32 times more likely than controls to have pRBD.





## CTE research globally



## What will the next 1,000 brains mean for research?



*"The discoveries made in the brain bank have inspired the treatment regimens we prescribe to patients who come to our clinic with symptoms that may be due to CTE. My colleague Dr. Andrew Budson and I wrote up our advice in Management of Chronic Traumatic Encephalopathy, and we will continue to update and refine treatment protocols as we learn more."*



*"The VA-BU-CLF Brain Bank has provided evidence that a football player's odds of developing CTE increase with each year played, and the younger one starts, the earlier CTE symptoms may develop. This inspired CLF's Flag Football Under 14 campaign, which encourages parents to wait until high school to enroll their children in tackle football. We believe that simple change might prevent 50 percent of football CTE cases. We are eager to expand this research to other sports, but we need a larger sample size."*

-Dr. Chris Nowinski



## What will the next 1,000 brains mean for research?



*"Our understanding of CTE is far behind that of other neurodegenerative diseases like Alzheimer's Disease and ALS. Each case we have the honor to study accelerates the science of CTE. Thanks to our Legacy Donors, incredible team, and growing national and international collaborations, we are now on the cusp of major breakthroughs."*

-Dr. Ann McKee



*"Our understanding of the clinical presentation and course of CTE has grown through each and every one of the 1,000 Legacy Donors and informed the recently published 'NINDS Consensus Diagnostic Criteria for Traumatic Encephalopathy Syndrome (TES).' Moreover, due in large part to our ability to translate what has been learned through the VA-BU-CLF Brain Bank research into clinical studies of new biomarkers (including the possibility of blood tests), we are now getting incredibly close to being able to detect and diagnose CTE during life!"*

-Dr. Robert Stern



## Testimonials from Legacy Families



*"I'm very grateful for the insight the Concussion Legacy Foundation has been able to provide me and my family. Losing my dad without warning was a tough kick in the gut, but one of the saving graces of his passing was coming to understand just how healthy his brain was."*

*As a professional wrestler his entire life, his brain endured a lot. I know he'd be proud knowing the donation of it has impacted brain research and hopefully can shed some light and understanding, not only in science, but also to other families around the world.*

*Thank you to my good friend, Dr. Chris Nowinski and his brilliant cadre of doctors for their research."*

*-Dwayne "The Rock" Johnson, son of Rocky Johnson*



## Leaving a Legacy through brain pledging



*"People say, 'Oh, you left a legacy for the next generation.' This would be a more substantial legacy — something that could protect and save some kids, and to enhance and lift up soccer in a way that it hasn't before."*

*-Brandi Chastain, USWNT icon*



*"CTE is no joke and I don't want to see anyone else suffer like me and my friends. This is literally a life-and-death matter, and it's time we start having real, honest conversations about brain trauma in professional and youth sports."*

*-Leonard Marshall, 2x Super Bowl Champ*

**Pledge your brain at [PledgeMyBrain.org](https://PledgeMyBrain.org)**



## Project Enlist



- Mission: to serve as a **catalyst for research** on military Veterans with TBI, CTE, and PTSD by rapidly increasing the number of Veteran brains donated to brain banks for study.
- Why it matters: Brain bank research is an essential step in **developing effective treatments for TBI, CTE, and PTSD** so we can protect and support the heroes who courageously fight for our nation.
- Vision: Project Enlist will create a **culture of brain donation** within the military community, while also providing a service to Veterans through positive brain health messaging.

**Learn more at [ProjectEnlist.org](https://ProjectEnlist.org)**





## Behind-the-scenes heroes



**Dr. Victor Alvarez**



**Lisa McHale**

### Brain Processing Staff

Amina Burgess  
Erin Dixon  
Camille Esnault  
Steevens Excellent  
Lucas Fishbein  
Sarah Horowitz  
Daniel Kirsch  
Robert McCormack  
Raymond Nicks  
Arsal Shah

### 24-Hour Brain Donation Hotline Staff

Bobak Abdolmohammadi  
Evan Nair  
Nicole Saltiel  
Arsal Shah  
Madeline Uretsky

### Histologists

Kerry Cormier  
Caroline Kubilus  
Anthony Lapiana  
Rebecca Mathias



**ConcussionFoundation.org**

You can see Chris discussing CTE and the brain bank:

<https://www.youtube.com/watch?v=8jdvTdHwqSk&list=PL25DpcVTe-bRXKpAmsv0em2tTi55W6Stz&index=1>

See the call for no tackle football for children under 14:

<https://www.today.com/video/brett-favre-urges-no-tackle-football-for-kids-under-14-in-new-psa-118859845821>