MOTION MATTERS! GEOFFREY DYSON LECTURE 2016

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Being able to move effectively is fundamental to quality of life. Understanding the mechanisms of injury and risk factors, and introducing interventions to reduce inappropriate forces, are key to being a successful sports injury biomechanist. Applied research in rugby, rowing and other sports, where the gap between biomechanics research and practice has been bridged, is outlined. The use of sports technology developments to answer athlete focused and coach driven questions is described. Translation of biomechanics knowledge into SportSmart and its derivative programmes has provided practical information for coaches and athletes, helped change attitudes and behaviours towards injury prevention and helped reduced injuries. Take home messages for biomechanists on why motion matters are provided based on my career and life experience learnings.

KEY WORDS: injury biomechanics; sports performance; rugby; rowing; gymnastics; technology.

INTRODUCTION: Being able to move effectively is fundamental to quality of life. From activities of daily living to elite sport performance, the human body has incredible capacity for development of movement ability. Losing the ability to move effectively and efficiently highlights the importance of human motion. The Olympic motto Citius, Altius, Fortius means faster, higher, stronger. As sports biomechanists we are asked to help improve technique so athletes can run faster, jump higher, and lift, push or carry objects. Understanding the mechanisms of injury and risk factors, and introducing interventions to reduce inappropriate forces, are the keys to being a successful sports injury biomechanist. It is a balancing act as recommendations to reduce injury risk may also reduce performance in the short term. In my opinion, sports biomechanists have a responsibility to help improve movement in athletes and in the general population for the wellbeing of humankind.

AIM & METHODS: The aim is to outline why motion matters and why biomechanists are important to society in helping make a difference to human performance. I reflected on my life experiences and research career that has focused on the advancement of theory and practical application in sports performance and injury biomechanics. I selected research where I actively collaborated with coaches and bridged the gap between research and practice – which is a primary purpose of the International Society of Biomechanics in Sports (ISBS).

RESULTS: ***Rugby union and league injury biomechanics.*** Several key questions our rugby codes research group have attempted to answer include: What is the nature, cause and mechanisms of injuries? What are the long term health outcomes of playing rugby and effects of concussion? What interventions can help reduce injury?

Doug King conducted prospective observational epidemiology analyses for tackle-related injuries and video analyses for the nature of tackles for a team in the National Rugby League throughout the 2007 and 2008 competitions. As a result of this work, club level rugby league medical personnel are now being trained in dealing with neck, spine and head related injuries. There is now focus on increasing awareness of correct tackling technique, head injury awareness and management of suspected cervical spine injuries in player and coach education programmes we helped develop. Doug continued to have questions about concussion in sport. During Doug's second PhD, monitoring rugby players' head impacts with triaxial accelerometers in behind-the-ear patches and instrumented mouthguards showed that the size and frequency of impacts in rugby were greater than most other sports (King, Hume, Brughelli, & Gissane, 2014). As technology advances, the issue is how best to use the technology to help sport answer their questions.

Our IRB/NZRU/AUT RugbyHealth study reported long term health outcomes for 485 retired players, many who had sustained multiple concussions (Hume, Quarrie, Lewis, & Theadom, 2015). The project described differences between 131 retired elite rugby players, 281 retired community rugby players and 73 retired cricket players in New Zealand. Using an on-line general health questionnaire, ex-rugby players had a greater proportion of injuries during sport including concussions, and arthritis and alcohol use concerns currently. Ex-rugby players reported a wider range of health issues than non-contact sport players. Using the on-line CNSVS test there were more neuro-cognitive deficits in retired elite rugby players and community rugby players than non-contact sport players. Retired players who experienced concussion had worse cognitive flexibility (switching attention between tasks) and processing speed (ability to understand and process information quickly) than retired players with no history of concussion. Elite and community rugby groups performed worse on tests of complex attention, cognitive flexibility, processing speed and executive function compared to the non-contact sport group. Our laboratory measurements using electromagnetic induction showed that corticomotor and intracortical brain excitability was intact in elite and community level rugby players in comparison to non-contact sport players. There were no clear differences in any corticomotor excitability measures among groups with or without previous concussion. Changes in balance via centre of gravity, ground reaction forces and body position during laboratory exercises were measured. Players with no self-reported concussion had better balance than retired players with concussions.

Rowing biomechanics. National rowing coach Dick Tonks asked me how can we make the boat go faster? One of my first PhD students Clara Soper identified that changing foot-stretcher angle influenced performance resulting in use of optimal foot stretcher angles in training and competition (Hume, Soper, Reid, & Tong, 2005). Rowing New Zealand then purchased a new boat instrumentation system to allow us real-time collection of oar pin forces, oar angles and boat velocity. Another of my PhD students Jennifer Coker was integrated into the Rowing New Zealand training centre at Lake Karapiro full time to evaluate the reliability and validity and use of the new system for rowing biomechanics feedback. Jennifer's thesis results helped provide valid methods for measuring elite rowing technique and boat set-up for on-water rowing performance. Original technology used with rowing in 2001 was the Goggles Training System (GTS) that allowed real time feedback of video and sound to the rower. We showed the GTS could significantly reduce lumbo-pelvic angle for rowers. Dick and other coaches used the system to change technique and reduce the risk of back injuries (Hume, Soper, & Zeinstra, 2005). Our recent studies at the request of Dick, have used a novel foot-stretcher with a rigid wedge shoe fixed at a pivot around the heel, allowing contact of the whole foot surface to the foot-plate throughout the entire stroke. Performance over 500-m improved with the novel foot-stretcher, and comfort ratings were good, in comparison to the current standard foot-stretcher.

Active engagement with sports for applied biomechanics. Internal and external risk factors when combined with the mechanism/inciting events of injury may make an athlete more prone to injury (Hume, Bradshaw, & Bruggeman, 2013). Active engagement to provide an athlete centred, coach driven approach is most effective to help improve performance and reduce injury risk. In Peter Maulders' PhD, with Netball New Zealand, both high and low joint coupling variability of the lower limb during change of direction tasks appeared beneficial for reducing injury risk. Intervention programmes designed for netballers now focus on developing a large repertoire of coupling strategies for use during unanticipated movement tasks.

Collaboration with Auckland Blues Rugby, and New Zealand Rugby League Warriors, enabled Scott Brown to conduct functional screening of rugby players using isokinetic dynamometry, balance and cutting movement assessment to help identify risk of lower limb injury in his PhD. Sidestepping with a ball resulted in greater knee adductor moments during weight acceptance than without a ball. Biomechanics evaluation for athletes in sport needs to include the implement/ball to ensure accurate understanding of movement patterns.

Anna Lorimer's PhD, in cooperation with 75 Triathlon New Zealand athletes, reported that triathletes who developed a new or reoccurring injury during a one-year prospective surveillance period had higher leg and knee to ankle stiffness ratios compared to controls. Stiffness can be measured relatively easily so may be a potential screening tool for athletes using an individual responses approach (Lorimer & Hume, 2016). Incorrect bicycle configuration may predispose athletes to injury and reduce cycling performance.

Rodrigo Bini's PhD reported that given conflicting evidence for effects of saddle height changes on performance and lower limb injury risk in cycling, the saddle height may be set using the knee flexion angle method to reduce the risk of knee injuries and to minimize oxygen uptake (Bini, Hume, & Croft, 2011).

An innovative approach has been the development of a coach-friendly customized infra-red timing gate and contact timing mat system operated by the coach to augment feedback provided to gymnasts on their vaulting performance during regular training (Bradshaw, Hume, Calton, & Aisbett, 2009). Approach velocity and board contact time measures were reliable measures during vault training. We have been validating innovative field-based techniques to enable large-scale screening programs for injury-prediction measures of neuromuscular control and valgus loading of the knee in gymnasts.

Translation into practice. No research will make a difference unless it is translated into real world use. Translation of sports biomechanics and injury prevention knowledge into practical information for coaches, athletes and administrators can help change attitudes and behaviours and help reduce injury risk. I developed the original New Zealand SportSmart 10-point plan for injury prevention in 1999 (Hume & Potts, 1999). The sport specific adaptions such as RugbySmart and NetballSmart, have incorporated best practice from scientific evidence of injury prevention strategies into education programmes. The use of biomechanics information in the technique, environment, screening, warm-up and conditioning points in particular have been useful to help reduce injury risk. For example, RugbySmart is compulsory for coaches and referees in tackle grade rugby with over 8,000 coaches and 2,000 referees accredited each year. RugbySmart was introduced in 2001 with a corresponding decrease in the number of severe spine-neck injury claims (Quarrie, Gianotti, Hopkins, & Hume, 2007). Dental injuries also reduced after the introduction of RugbySmart which targets the use of mouth guards and correct tackling technique (Gianotti, Quarrie, & Hume, 2009). A 2008 editorial in British Journal of Sports Medicine stated that it was time for other nations to follow New Zealand's success of the SportSmart injury prevention model. Evaluation of South Africa BokSmart for rugby has shown a positive effect for injury reduction.

CONCLUSIONS: My life experiences as an athlete, coach, kidney transplant patient, sport scientist and educator have enabled me to communicate with people to help them improve their movement quality and capacity. Understanding mechanisms of injury and risk factors, and introducing interventions to reduce inappropriate forces, are key to being a successful sports injury biomechanist. Translation of biomechanics knowledge into the SportSmart programme and its derivative programmes has provided practical information for coaches and athletes, has helped change attitudes and behaviours towards injury prevention and has helped reduce injuries. I suggest you use a relevant questions approach to guide your research and practice. Gain inspiration from coaches and athletes questions. Be creative in your approach to questions to help advance knowledge through originality. Use technology and resources wisely. Use a questions approach, not a tool-technique based approach as a priority. Be people oriented. Actively engage with athletes and coaches. Use teamwork to enable mentoring of skills, active discussion and idea generation. Use a multidisciplinary approach and networking to ensure the best people are on project teams and there is opportunity development. Motivate others to be the best we can be by being engaging and willing to share experiences. As biomechanists we need to enjoy lifelong learning by continuing to educate ourselves and by educating and advising others. Ensure you provide high quality training programmes in sports biomechanics with input from athletes and coaches. Take opportunities for informal learning from others and provide opportunities for others to learn from you. Mentor others to be curious and challenge them to be the difference rather to just make a difference. Evaluate the effectiveness of your work. Does it actually make a difference? Success leads to success, so surround yourself with positive actively contributing people. Human motion matters, and sports biomechanists have a responsibility to help improve movement quality and capacity. Bridge gaps with coaches, athletes and other sport scientists.

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