Institution: **University of Bath**

Unit of Assessment: **26: Sport and Exercise Sciences, Leisure and Tourism**

Title of case study: **Reducing the Impact of Injury & Illness in Challenging Environments**

1. Summary of the impact

Research at the University of Bath has had a significant impact on reducing the burden of injury and illness in military training and sport. We have engaged practitioner communities in evidence-based approaches to injury and illness prevention. Our research has contributed directly to reducing the burden of musculoskeletal injuries and heat illness by informing military personnel selection, training and healthcare policies. This affects approximately 20,000 military trainees per year and has resulted in reduced morbidity and estimated training/medical costs of over £60 million per annum. Our injury surveillance research has helped shape the Rugby Football Union's (RFU) medical safety policy and, based on our research, the International Rugby Board (governing 5 million players worldwide) announced in May 2013 a global trial of new scrum laws designed to reduce the incidence/severity of neck injuries.

2. Underpinning research

The aim of the research described in this case study is to understand the burden of musculoskeletal injuries and training-related illnesses in order to maintain and improve function in sports performers and personnel employed in arduous occupations. The focus is on understanding the scale of the injury/illness problem, identifying the independent risk factors and then establishing and evaluating appropriate interventions to reduce injury/illness incidence and/or severity. This research is part of the Injuries, Illnesses and Disability theme within our Integrative Human Performance group. The researchers who have contributed to this case study include Dr Keith Stokes (appointed 2001, Senior Lecturer), Dr Grant Trewartha (appointed 2001, Senior Lecturer), Dr James Bilzon (appointed 2008, Senior Lecturer) and Dr Ezio Preatoni (appointed 2012, Lecturer).

Research into injuries and illnesses has been supported by grants to the University of Bath of >£1.8 million from the Ministry of Defence (MOD), Rugby Football Union (RFU), Injured Players Foundation and the International Rugby Board (IRB). Since international and national sports governing bodies and government agencies with stakeholder interest fund our research, there is a direct and immediate route to impact.

Musculoskeletal injuries and illnesses in the military

Collectively, our research conducted in partnership with the MOD identified physical fitness, energy balance, training progression, lower limb biomechanics and cigarette smoking as independent risk factors for musculoskeletal injury. Specifically, one holistic study conducted in partnership with Optimal Performance Ltd identified that the physical fitness selection standards were inappropriate, the physical training programme was not progressive in nature and the dietary energy provision for Parachute Regiment trainees was 1000 kcal/day less than energy expended during training [1]. Specific recommendations, addressing each of these issues, were implemented and subsequently evaluated. A further randomised controlled trial demonstrated a 50% reduction in lower limb injuries among Royal Navy Officer Cadets following personal orthotic insole intervention [2]. This study was conducted in partnership with Dr Andrew Franklyn-Miller, a sports medicine physician based at the Defence Medical Rehabilitation Centre Headley Court and as part of a University of Bath PhD studentship (supervised by Bilzon). Based on our earlier findings, and having previously noted the high incidence of Exertional Heat Illness casualties in Parachute Regiment training [1], we conducted a further MOD-funded prospective cohort study to assess incidence and pathophysiology of Exertional Heat Illness in military trainees [3]. This study was conducted under a MOD research contract to Bath (see Grant 2) and in collaboration with Professor Neil Walsh (Bangor University) and Professor Simon Jackson (University of Plymouth). The findings

highlighted the relatively high incidence of Exertional Heat Illness during different military training events (5-10%) and the misclassification of the condition and associated treatment by medical and training staff [3]. This research also suggested a role for immune disturbance, particularly during long duration (>45 min) exercise, something that could potentially be managed.

Musculoskeletal injuries in sport (rugby)

Our partnership with the Rugby Football Union (RFU) has taken an epidemiological approach to understand injuries in a series of studies (Grants 3-5) in youth, community, premiership and women's Rugby Union [4]. These findings quantify for the first time at all levels of the game the relatively high incidence of injury associated with tackling and the high severity of injuries associated with the scrum [4]. This has led to further mechanistic studies, funded by the IRB (Grant 6), that demonstrate the differences in player impact forces in the scrum when adopting different methods of engagement with the opposition [5]. Importantly, these studies demonstrated that impact forces in the scrum can be reduced by changing the initial contact [5].

3. References to the research

Peer-Reviewed Journal Articles

1. Wilkinson DM, Rayson MP and Bilzon JLJ. (2008). A physical demands analysis of the 24-week British Army Parachute Regiment recruit training syllabus. *Ergonomics*, **51**: 649-662. (doi: 10.1080/00140130701757367).
2. Franklyn-Miller A, Wilson C, Bilzon JLJ and McCrory P. (2011). Foot orthoses in the prevention of injury in initial military training: a randomized controlled trial. *American Journal of Sports Medicine*, **39**: 30-37. (doi: 10.1177/0363546510382852).
3. Bilzon JLJ, Jackson S & Walsh NP. (2012). A Prospective Cohort Study to Investigate the Incidence and Pathophysiology of Exertional Heat Illness (EHI) in Parachute Regiment Trainees. *University of Bath Report to HQ ARTD dated 6 August 2012*.
4. Palmer-Green DS, Stokes KA, Fuller CW, England M, Kemp SPT and Trewartha, G. (2013). Epidemiological study of match injuries in English youth academy and schools rugby union. *American Journal of Sports Medicine*, **41**: 749-755. (doi: 10.1177/0363546512473818).
5. Preatoni E, Stokes KA, England M & Trewartha G. (2013) The influence of playing level on the biomechanical demands experienced by rugby forwards during machine scrummaging. *Scandinavian Journal of Medicine and Science in Sports* **23**: 178-184. (doi: 10.1111/sms.12048).

Grants

1. Dr Keith Stokes (Principal Investigator), Dr Dylan Thompson, Dr James Bilzon. Influence of smoking on performance and physiological status during initial training. Headquarters Army Recruiting & Training Division, Ministry of Defence. 2008-2011. £95K.
2. Dr James Bilzon (Principal Investigator), Dr Neil Walsh (Bangor), Professor Simon Jackson (Plymouth).Incidence and pathophysiology of Exertional Heat Illness in Parachute Regiment trainees. Directorate of Army Personnel Strategy (Research), Ministry of Defence (Army). 2008-2011. £95K.
3. Dr Keith Stokes (Principal Investigator), Dr Grant Trewartha. Injury risk in English community rugby union. Rugby Football Union / Injured Players Foundation. 2008-2012. £229K
4. Dr Keith Stokes (Principal Investigator), Dr Grant Trewartha. Injury risk in English Premiership Rugby Football Union. Rugby Football Union/Premier Rugby Limited. 2011-2015. £193K.
5. Dr Keith Stokes (Principal Investigator), Dr Grant Trewartha, Dr Gavin Shaddick (Department of Mathematical Sciences, University of Bath). Community Rugby Injury Surveillance Project (CRISP). Rugby Football Union/Injured Players Foundation. 2012-2017. £283K.
6. Dr Grant Trewartha (Principal Investigator), Dr Keith Stokes. Biomechanics of the rugby scrum. International Rugby Board (IRB). 2010-2013. £540K.

4. Details of the impact

Researchers at Bath have had significant impacts on reducing the burden of injuries and illnesses in both sport and military training environments. These impacts include knowledge transfer and engagement with key stakeholder groups (e.g. practitioners), as well as changes to policy, practice and outcomes with regards to personnel/player welfare. Although wider research dissemination is relatively recent, our stakeholders have acted immediately based on the conclusions and recommendations submitted in earlier reports, often long before journal publications.

Musculoskeletal Injuries in Military Training.

Based on our analysis of British Army Parachute Regiment training [1] the Ministry of Defence implemented (i) evidence-based physical selection criteria, (ii) a 2-week increase in training duration and (iii) the introduction of a 1000 kcal per day nutritional training supplement in (High Activity Training Supplement (HATS), implemented by Defence Food Services Agency (DFSA) in 2008) [7]. This intervention has resulted in an increase in recruit success rates during Parachute Regiment training (from 43 to 58%) and a substantial reduction of all-cause medical discharge incidence during training from 14 to 5% [8]. The decision to implement this intervention across all three military services was not taken lightly by the MOD (the cost of implementation is ~£2.5 million per annum). Furthermore, the nutritional supplement component has now been implemented throughout all military initial training, thus benefiting approximately 20,000 trainees per year, or 80,000 trainees since inception in 2009 [7]. Early findings were disseminated to practitioners at the Occupational & Environmental Medicine Conference in November 2008 [8] and more complete analyses to the Military Rehabilitation Conference at the ExCel in London in November 2010 [9]. Whilst the initial research was focussed on Parachute Regiment trainees, it has been used more generally to inform wider British Army training policy and practices – for example, via the implementation of physical selection standards and more progressive training regimens throughout the army [10]. Our orthotic insole intervention research with Royal Navy Officer Cadet trainees has also resulted in a 50% reduction in time-loss lower limb injuries among trainees [3], and has been implemented across the Royal Navy, affecting some 3000 trainees per annum. It has also been used to inform and direct related British Army research, leading to the implementation of a related training risk reduction model [11]. As a result of research and expertise in this area, Dr Bilzon was appointed by the Director General Army Medical Services to act as Honorary Civilian Consultant Advisor in Sport & Exercise Science in January 2012. Based on conservative estimates from British Army training alone, a health economist has estimated that, collectively, this research into musculoskeletal injuries in the military has contributed directly to an annual training delivery cost-saving of £49 million associated with training completion rates and an additional £13.5 million saving associated with a reduction in injury incidence since 2009 [10].

Exertional Heat Illness in military training.

A primary outcome from this research was that the incidence of exertional heat illness was relatively high, ranging from 5-10% across the training events monitored [4], affecting approximately 500 trainees per year. Furthermore, casualties were not being appropriately diagnosed and treated. Our demonstration that all casualties had core body temperatures >39.5˚C has heightened awareness of the gravity of the issue and led to immediate changes in Army Recruiting & Training Division medical guidance to training establishments on the prevention and treatment for heat-related illnesses. This included the use of the Glasgow Coma Scale to monitor levels of consciousness and reporting to the medical centre for clinical observation. This research was presented to the Army Recruiting & Training Division Research Working Group in 2010 and recommendations incorporated into MOD-wide policy and medical research strategy. Our research has therefore contributed directly to changes in trainee healthcare policy, whereby all suspected heat illness cases will be referred to the medical centre for monitoring and observation in a controlled environment. This has and will continue to reduce the risk of relapse and secondary complications among ~12,000 otherwise healthy British Army trainees per annum [10].

Musculoskeletal Injuries in Sport – impact from injury surveillance research.

The long-term injury surveillance research programmes from Bath that are in place across the whole array of Rugby Union, from youth to premiership rugby, have generated specific

recommendations that are being used by the RFU across all levels of rugby in their medical safety policy and have been embedded into RFU coaching courses such as 'Rugby Ready' since 2010 [12]. Over 10,000 adults per year undertake the 'Rugby Ready' coaching course alone [12]. The implications and messages from our research are disseminated by annual [13] and game-wide reports [14], user group meetings, RFU-assisted dissemination to players and coaches, and presentations by RFU medical directors to the International Rugby Board annual medical conferences (to which representatives from all 100 member unions and 17 associate member unions are invited). Recommendations regarding player technique, design of training and competition schedule to reduce injuries in youth rugby have been disseminated to >3000 schools, elite rugby academies and teams in the RFU club network. As a result of expertise in this area, Dr Keith Stokes was appointed as the Sports Science Advisor to the RFU Medical and Sports Science Advisory Group in February 2013 and Drs Stokes and Trewartha were appointed to the IRB Scrum Steering Group in 2010 [15]. Further, from September 2013, the RFU have commissioned Bath to deliver an injury prevention programme to schools players based on our findings in youth rugby.

Musculoskeletal Injuries in Sport – impact from mechanistic intervention trials.

Our epidemiological findings that the scrum represents a disproportionate source of acute injuries led to a specific and large international programme on the biomechanics of scrummaging, which involved **"***an extensive process of testing and analysis at all levels of the Game within the unprecedented IRB funded Scrum Forces Project run by the University of Bath in conjunction with the RFU***"** [15] and in May 2013 the IRB announced a global game-wide trial of new Laws for a modified scrum engagement sequence underpinned by our research [15]. Independently, our research has been highlighted and utilised by the South African Rugby Union in changing scrum laws at youth and community levels [16]. Overall, the greater awareness of the injury problem and strategies for injury prevention is now the subject of an international IRB-hosted Rugby Science Network, which is edited and run by Bath-based scientists [17]. The website provides an interactive discussion forum for over 600 active practitioners and researchers and over 2300 twitter followers around the world.

5. Sources to corroborate the impact

[7] e-mail from Principal Scientist, Defence Science & Technology Laboratories, dated 25 October 2013. Confirming impact and implementation of research on MOD training and service feeding policy and practice.
[8] Bilzon JLJ. (2008). Prevention of Musculoskeletal Disorders in British Army Training: Evidence-based Interventions. Presentation to the University of Birmingham's Institute of Occupational & Environmental Medicine (IOEM) Annual Conference, 12-13 November 2008.
[9] Bilzon JLJ. (2010). Metabolic and thermal strain during military training. Presentation to the Ministry of Defence's Annual Rehabilitation Conference, ExCel, London, November 2010.
[10] Letter from Director of Defence Rehabilitation dated 3 July 2013. Confirming overall impact on recruit training and associated medical and economic efficiencies.
[11] Sharma J, Golby J, Greeves J, Spears IR. (2011). Biomechanical and lifestyle risk factors for medial tibia stress syndrome in recruits: a prospective study. *Gait & Posture*, **33**: 361-365. (doi: 10.1016/j.gaitpost.2010.12.002).
[12] Letter from the RFU Community Rugby Medical Director, June 2013.
[13] English Professional Rugby Injury Surveillance Project Report 2011-12
http://www.rfu.com/news/2013/march/news-articles/200313_injuryaudit
[14] Palmer-Green DS, Trewartha G and Stokes KA (2011) Report on injury risk in English youth rugby union. RFU report distributed May 2011.
[15] International Rugby Board press release about the new scrum laws. 8 May 2013
http://www.irb.com/newsmedia/mediazone/pressrelease/newsid=2066642.html
[16] Email from Wayne Viljoen, Manager of BokSmart, South Africa Rugby's Safety Programme, September 2013
[17] IRB Rugby Science Network: http://www.irbsciencenetwork.com