

Institution: University of Brighton		
Unit of Assessment: C24 Sport and Exercise Sciences, Leisure and Tourism		
Title of case study: Protecting the Health of Paralympic, Olympic and World Cup competitors		
Period when the underpinning research was undertaken: 2002 – ongoing		
Details of staff conducting the underpinning research from the submitting unit:		
Name(s):	Role(s) (e.g. job title):	Period(s) employed by submitting HEI:
Mark Hayes	Senior Lecturer	2011 – to date
Neil Maxwell	Reader	1997 – to date
Peter Watt	Associate Professor of Sport and Exercise Medicine	2001 – to date
Nick Webborn	Clinical Professor	2004 – to date
Period when the claimed impact occurred: 2013 – 2020		
Is this case study continued from a case study submitted in 2014? N		
1. Summary of the impact <p>University of Brighton (UoB) research has led to changes in International Paralympic Committee (IPC) policy and practice concerning the health and safety of Para athletes and the integrity of the fair and competitive sporting model. This has benefitted the preparation for, and performance of, 10,000 Para athletes at three Paralympic Games (2014 – 2018). Epidemiological studies initiated in 2002 into the incidence of sport injuries and health issues at Paralympic Games have determined the regulations for all participants, creating a safer competitive environment and reducing injury levels. UoB's work on environmental extremes has produced evidence-based strategies enabling competitors, doctors and their support teams in Team GB at Tokyo 2021, and England Rugby at the men's World Cup 2019, to prepare for and engage in sport more safely.</p>		
2. Underpinning research 2.1 Protecting the Para athlete: Identifying the research challenges <p>Over the last 20 years sport science/sport medical research at UoB has identified contextual and environmental factors determining outcomes in athletic performance and competition. This included work on altitude and performance thresholds, constraints inhibiting the performance of tetraplegic athletes, and pioneering interventions on environmental extremes. Since 2002, Professor Nick Webborn, Dr Neil Maxwell and Professor Peter Watt have led programmes of research examining selected contexts of athletic performance and achievement, including collaborative work on heat acclimation [Reference 3.1]. Webborn, in the specialist sphere of Para athlete performance and competition, has undertaken injury data collection and analysis on seven Paralympic Games. The development of the formal study design, questions and protocols for collection was led by Webborn, receiving ethical approval from the UoB in 2009. Initial data analysis identified that several of the more severe injuries were preventable and demonstrated that ongoing research could inform injury prevention programmes and policy considerations regarding athlete safety. The research, conducted in collaboration with international specialists from the USA, Canada, Sweden, South Africa and the IPC Medical and Scientific Department, Germany, is now a responsibility of the IPC Medical Committee. Since 2012 a web-based injury and illness surveillance system (WEB-ISS) has generated data on injuries and illness at the Winter and Summer Paralympic Games with full analysis completed by Webborn and IPC colleagues [3.2].</p> 2.2 From Reactive to Proactive Intervention and Health Protection of Para Athletes <p>Continued research has provided a longitudinal dataset that enables long-term monitoring and comparative analysis of occurrence of injury and illness over time and identifies <i>in situ</i> contexts</p>		

and conditions in which Para athletes acquire injury. In Winter Paralympic Games settings, athletes report higher incidence of injury and illnesses than do Olympic athletes or athletes in a Summer Paralympic Games [3.3]. The first data set from the Summer Paralympic games in London 2012 included pioneering comprehensive studies of illnesses in Para athletes, confirming their unique illness profile, at approximately twice the level of Olympic athletes [3.2]. The London 2012 research identified two critical injury profiles. The most common injury category overall was upper limb injuries, occurring at the highest rate in wheelchair athletes, with important implications for maintaining independence in later life. The 2012 data also found that Visually Impaired (VI) five-a-side football had the highest risk of injury in all sports, verified by further data collected at Rio 2016. In 2012 more than 30% of players sustained an injury, of which head and neck injuries accounted for 25% of the acute injuries [3.2]. Webborn's further research into head injuries in VI five-a-side football has identified a need for better surveillance and reporting on head injury and concussion, recommending trialling protective headgear, and more rigorous enforcement of existing rules and regulations [3.4]. Across the 2012 games, data analysis showed a high risk of head injuries and concussion among Paralympic athletes in multiple sports, including the unexpected finding of concussion occurring in wheelchair track athletics. Webborn's work in this field includes his co-founding contribution to the work of the Concussion in Para Sport Group, with IPC medical committee colleague Kissick. Webborn's research has provided evidence to eliminate the life-threatening malpractice of 'boosting' and its threat to fair competition. Boosting describes the intentional induction of autonomic dysreflexia, a phenomenon which can occur naturally in people with spinal cord injury (SCI) and can produce a marked rise in blood pressure which can enhance performance for some wheelchair racers but can also have catastrophic effects including death, stroke, seizures and myocardial infarctions. Dysreflexia is indicated by measuring systolic blood pressure change. In a World Anti-Doping Agency (WADA)-funded project in 2008 Webborn and colleagues identified that 16.7% of a sample of Para athletes admitted to using boosting during training and/or competition, and 25.5% of the participants reported that the process was very dangerous to health [3.5].

2.3 Reducing the effects and risks of heat factors in elite competition

UoB research into environmental impacts on physical performance and health extends back to before 2000. It has since produced a body of work providing evidence for effective preparation, and countermeasures to environmental factors threatening health and performance. These publications comprise peer-reviewed papers, complemented by lay articles and reports for professional bodies. Collaborative work in the Environmental Extremes Lab (EEL) has established a cognate group of researchers including Maxwell, Hayes, Webborn, and Watt, investigating the impact of heat and other environmental effects (altitude and cold) on human health and function. Their research has generated evidence and effective strategies for improving safety, performance, and preparing the body for competition in inhospitable environments such as at the Marathon des Sables, and in hot, humid conditions similar to those experienced in summer Olympic Games. The research has also identified heat and exercise issues for Para athletes, who may experience thermoregulatory issues arising from their physical disability. Accumulatively, these research findings show the importance of preparatory strategies for implementation in athletic competition; for instance, analysis of pre-performance heat acclimation for intermittent cycling sprint protocols established the efficacy of heat acclimation for an increase in peak power, with no observed reduction in individual sprint peak power output [3.1]. Analysis of heat strain and running performance by Maxwell and Hayes expanded the heat acclimation work across the athlete spectrum in relation to conditions of heat and humidity [3.6].

3. References to the research

- [3.1] Castle, P., Mackenzie, R.W, Maxwell, N., Webborn, A.D.J., & Watt, P.W. (2011), Heat acclimation improves intermittent sprinting in the heat but additional pre-cooling offers no further ergogenic effect, *Journal of Sports Sciences* 29(11), 1125-1134.
DOI:10.1080/02640414.2011.583673 [Quality validation: peer-reviewed journal].
- [3.2] Derman, W., Schwellnus, M., Jordaan, E., Blauwet, C., Emery, C., Pit-Grosheide, P., Patino Marques, N., Martinez-Ferrer, O., Stomphorst, J., Van de Vliet, P., Webborn, N., Willick, S. (2013), Illness and injury in athletes during the competition period at the London 2012 Paralympic Games: development and implementation of a web-based surveillance system

(WEB-IISS) for team medical staff, *British Journal of Sports Medicine* 47(7), 420-425.
DOI: [10.1136/bjsports-2013-092375](https://doi.org/10.1136/bjsports-2013-092375) [Quality validation: peer-reviewed journal].

[3.3] W. Derman, M. P. Schwellnus, E. Jordaan, P. Runciman, P. Van de Vliet, C. Blauwet, N. Webborn, S. Willick, J. Stomphorst (2016), High incidence of injury at the Sochi 2014 Winter Paralympic Games: a prospective cohort study of 6564 athlete days, *British Journal of Sports Medicine* 50(17), 1069-1074. DOI: [10.1136/bjsports-2016-096214](https://doi.org/10.1136/bjsports-2016-096214) [Quality validation: peer-reviewed journal].

[3.4] Webborn, N., Cushman, D., Blauwet, C. A., Emery, C., Derman, W., Schwellnus, M., Stomphorst, J., Van de Vliet, P., Willick, S. E. (2015), The epidemiology of injuries in football at the London 2012 Paralympic Games, *Physical Medicine and Rehabilitation* 8(6), 545-552.
<https://doi.org/10.1016/j.pmrj.2015.09.025> [Quality validation: peer-reviewed journal, the American Academy of Physical Medicine and Rehabilitation].

[3.5] Bhambhani, Y., Mactavish, J., Warren, S., Thompson, W. R., Webborn, A., Bressan, E. Tuilo de Mello, M., Tweedy, S., Malone, L., Frojd, K., Van de Vliet, P., & Vanlandewijck Y. (2010), Boosting in athletes with high-level spinal cord injury; knowledge, incidence and attitudes of athletes in Paralympic sport, *Disability and Rehabilitation* 32(26), 2172-90.
DOI: [10.3109/09638288.2010.505678](https://doi.org/10.3109/09638288.2010.505678) [Quality validation: peer-reviewed journal].

[3.6] Willmott, A.G.B., Gibson, O.R., Hayes, M., & Maxwell, N.S. (2016), The effects of single versus twice daily short term heat acclimation on heat strain and 3000 m running performance in hot, humid conditions, *Journal of Thermal Biology* (56), 59-67.
<https://doi.org/10.1016/j.jtherbio.2016.01.001> [Quality validation: peer-reviewed journal].

4. Details of the impact

UoB research provides evidence for best practice in preparing for athletic competition in environmentally challenging circumstances with effects reaching across the institutional structures, management and support for athletes competing in global sporting events. The research has provided strategies that put UoB's scientific evidence at the forefront of changes in decision-making and policy implementation delivering improved sporting environments that protect Paralympians, Olympians and other athletes in optimising sporting performance in differing conditions and maintaining the integrity of fair athletic competition.

4.1 International Olympic Committee (IOC) and International Paralympic Committee (IPC): effecting change from within

Webborn's research and expertise have framed and changed the research and policy agendas of the IOC and contributed to IOC consensus statements, delivering, in the words of the IOC Medical and Scientific Director, '*extensive and deep impact upon the evidence base that has informed decisions and strategies affecting IPC and IOC practices and policies*' [Source 5.1]. At the IPC, Webborn, recognised by the IPC President as '*one of the world's leading research scholars in the science and medicine of Para athlete sport*', has delivered research contributions that have been significant '*in meeting our primary goal of protecting the health of the athlete*' [5.2]. A long-standing member of the IPC medical committee, Webborn has led global responses to critical issues of safety in high-performance sport and competition. In particular, Webborn's research has '*put in place systematic programs of longitudinal data collection to indicate specific threats and dangers to the health of the Para athlete*' [5.2]. In the IPC's record of research publications on IPC Injury and Illness Surveys (updated June 2019), Webborn is an author on 18 of the 19 publications [5.2]. The IPC Medical Code pledges to protect and promote athlete health during training as well as in competition, its priorities including development of protocols for medical care at events, guidelines on periodic health evaluation for both athletes and officials, and advancement of health and wellbeing research. The IPC President states: '*Professor Webborn's research expertise has contributed to the IPC responses to all of these priorities*' [5.2]. His research has produced evidence empowering the medical and ethical committees of the IPC in its policy-making. Athlete safety, from the perspective of the individual athlete and the competitive environment, has been enhanced, through '*changes to guidelines thereby creating safer sites and environment*' [5.2]. At the IOC, leading sessions of the Advanced Team Physician courses, Webborn has demonstrated how his research-informed practice

combines a scientific and professional contribution that has *'sought consistently to educate, persuade and change for the better ... in an incremental process of evidence-based analysis and reform'* [5. 1]. Working from within the IPC and the IOC, Webborn has generated research studies and findings that determine a process delivering change that protects the health of Para and other athletes.

4.2 Improving the safety of the Para athlete environment

In collaboration with the International Paralympic Committee (IPC) Webborn has, since 2002, initiated a major systematic data collection programme that includes analyses of injury and illnesses in para athletes with the research identifying a worrying trend of increased acute Alpine skiing injuries. This accumulated data from sub-analyses has led to evidence-based recommendations for changes that address potential risk factors to improve training and performance conditions. These were implemented by the IPC in collaboration with the World Para Alpine Skiing management in 2018 [5.2]. Changes included: changes in course design, settings, start times to optimise environmental factors, and race safety guidelines implemented in conjunction with technical officials [5.3]. UoB's research has enabled changes in the practices of the International Blind Sport Federation (IBSA), designed to reduce injury and illness among para athletes. Data on head injuries in VI five-a-side football have generated improved surveillance of and reporting on head injuries and concussion, with the introduction of more effective headgear and reinforcement of existing regulations [5.2].

4.3 Shaping heat strategy for athlete safety

National sporting bodies in Brazil and the UK have adopted heat-related principles and practices as a result of research led by Watt, Maxwell and Hayes, changing how heat is addressed in the planning and staging of Olympic events and other international sport competitions. Brighton research was utilised by Brazil's National Olympic Committee to *'help overcome the issues around exercise in the heat and the effects of exercise in such conditions on fatigue and performance impairment'*, for all of Brazil's athletes competing across *'28 modalities'* (all Olympic disciplines) at the Rio 2016 Olympics [5.4]. In the multi-sport event Modern Pentathlon, UoB's research and knowledge *'were paramount to establish training and competition strategies related to the fatigue aspect in the heat, especially linked to ammonia metabolism'* [5.5]. These strategies were also employed at the Military World Games (South Korea 2015 and China 2019) and the Pan American Games (Canada 2015 and Peru 2019). National bodies, including Team GB and English Rugby Union, have used UoB's evidence and research-based preparation and education packages [5.6, 5.7]. In the lead up to Tokyo 2020 UoB signed an MOU with the English Institute of Sport (EIS) to develop the *'Tokyo 2020 Heat Resource Pack'*, designed to protect the health of athletes in competition. This has contributed to the development of the EIS heat optimisation strategy, providing preparatory procedures for the 2020/21 Olympic and Paralympic Games [5.8]. In February 2019 the British Olympic Association's Deputy Chef de Mission (Performance, Tokyo 2020 Olympic Games) approached the EEL team: *'we knew of the comprehensive 87-page resource Maxwell and his team had produced for the EIS and wanted to use this as an evidence-based foundation for all sports to use and develop for their individual needs, especially for those who may not have bespoke funding support'* [5.6]. The UoB *'research and expertise has been particularly valuable in relation to the introduction of alternative heat acclimation approaches to fit around training commitments'*, helping *'our practitioners to provide more rigorous and individualised heat alleviation methods to their teams'* [5.6]. As the Team GB Deputy Chef de Mission observes: *'crucially, we have been able to trial many of these methods and protocols both in the UK [and at] our pre-Games training base in the city of Yokohama, to enable us to best certify practical application and individualised benefits in readiness for the Games'* [5.6].

The UoB team also presented evidence-based advice to Team GB doctors and coaches relating to their own health, establishing guidelines for the most effective strategies for working safely in the heat for both athletes and their support teams [5.6]. UoB research also provided research-led resources and expertise for England Rugby (ER) on how to deal with heat during the Rugby World Cup event in Japan (2019). Aware of UoB's research into heat acclimation, ER approached the UoB team in 2018 and the team's *'knowhow and scientific rigour'* proved *'extremely valuable in its preparation for participation and competition'* at the event [5.7]. In its 24

recommendations in response to the 5 central elements of the ER draft heat acclimation strategy, the UoB research was a *'major contribution to the confirmation of the strategy'*, and *'allowed us to develop a potent heat preparation plan delivered over an optimal timeline comprising a bespoke individual approach using practical heat preparation methods ... the guidance adopted also reduced the chances of an exertional heat-related illness within the squad'* [5.7].

4.4 Protecting integrity and fairness of Para athlete competition

Pioneering studies led by Webborn identified a lower threshold for detecting boosting (the deliberate induction of autonomic dysreflexia), producing a subsequent drop in offenders among Para athletes. Research highlighting the ethical and medical aspects of 'boosting' resulted in a Boosting Testing Programme launched in 2008 by the IPC medical commission including Webborn. The collection of data over an 8-year period allowed a detailed analysis of the variation in blood pressure in athletes prior to racing. There appeared to be a small group of athletes who had readings at a dangerous level above 180 mmHg at first reading but came below the threshold on 2nd testing, who were suspected of intentional induction. Analysis carried out at the UoB proposed that the threshold should be reduced to 160 mmHg. This recommendation was accepted by the IPC Governing Board as important for fair competition and led the IPC to change the regulations with regard to boosting in April 2016 [5.9]. Webborn's research has *'led to changes in relation to acceptable, lower levels of blood-pressure threshold ... producing a decrease in offenders and avoiding catastrophic effects for Para athletes'* [5.1]. Following the reduced level, as the IPC President confirms, such effects have been eliminated by the creation of a *'deterrent effect'* [5.2], with no athletes exceeding 180 mmHg since the introduction of the lower level. Research delivering these anti-boosting procedures combines *'the medical science with beneficial health, and ethical, outcomes'* [5.1], thus protecting both the health of the athlete and the basis of fair sporting competition.

5. Sources to corroborate the impact

[5.1] Testimonial from International Olympic Committee (IOC) Medical Director, on use of Webborn's sport medical research across the operating structures of the IOC.

[5.2] Testimonial from President, International Paralympic Committee (IPC), that confirms how Webborn's research has delivered a sustained and scaled impact across IPC policy and practices that affect the health of para athletes.

[5.3] Derman, W., How can injury surveillance inform advances in sport safety: The case of Alpine skiing, International Paralympic Committee, 2018.03.08

https://www.paralympic.org/sites/default/files/document/180607092008152_02_How+can+injury+surveillance+inform+advances+in+sport+safety_Derman_Pyeong+Chang_2018_03_08.pdf

[Accessed on 8th March 2021]. The steps taken in Pyeongchang are evidenced on p. 17 of 19.

[5.4] Testimonial from Distinguished Expert of the Brazilian Olympic Committee (BOC). This confirms the BOC's *'confidence that evidence from strong scientifically rigorous experiments would provide the best basis for preparation and performance in the conditions experienced in Rio during the Games'*.

[5.5] Testimonial from Head Coach of Brazil Modern Pentathlon team, Rio 2016 Games.

[5.6] Testimonial from Team GB's Deputy Chef de Mission, Performance, Tokyo 2020 Olympic Games. This confirms the scale of input of the UoB team for the development of strategies towards Tokyo 2020.

[5.7] Testimonial from national strength and fitness coach of England Rugby. This confirms that the expert knowledge and advice of the UoB team was a major contribution to the confirmation of the heat strategy for the 2019 Rugby World Cup in Japan.

[5.8] The Tokyo 2020 Heat Resource Pack. Available as a PDF.

[5.9] Medical and Scientific Director of the IPC – Peter van de Vliet - International Paralympic Committee, April 2016, CHAPTER 4.3 Position Statement on Autonomic Dysreflexia and Boosting: https://www.paralympic.org/sites/default/files/document/180726114334276_IPC+Handbook_Chapter+4_2_Position+Statement+on+Autonomic+Dysreflexia+and+Boosting.pdf
<https://www.paralympic.org/news/ipc-tightens-rules-clamp-down-boosting>, 3 May 2016.

[Accessed on 8th March 2021].