

Institution: Nottingham Trent University
Unit of Assessment: C26 Sport and Exercise Sciences, Leisure and Tourism
Title of case study: Improving exercise performance in the heat
<p>1. Summary of the impact</p> <p>The research in this Unit has been conducted through the Sport, Health and Performance Enhancement Research Group (SHAPE). Dr Sunderland's unique research in this Unit has challenged and changed both academic thinking and real-world practices relating to heat acclimation and performing in hot environments.</p> <p>This research has made, and is making, a significant impact across the world improving both physical and cognitive performance across a range of sports from elite to recreational level. Examples include: providing a fitness training manual now being used by all international hockey umpires; acclimation and cooling strategies for international hockey players; acclimation for international athletes, international netball players and recreational and charity runners.</p> <p>Reach and Significance</p> <p>The beneficiaries of this work include international bodies and their players (e.g., GB Hockey, England Hockey, Wales Hockey, Scottish Institute of Sport, The International Hockey Federation [FIH], International Netball Players and the Australian Cricket Team); as well as national and recreational athletes (Marathon des Sables athletes, Loughborough Students Hockey Club, recreational and sporting clubs, players and athletes).</p> <p>2. Underpinning research</p> <p>Dr Caroline Sunderland's research incorporates three inter-related topics:</p> <p>a) Heat acclimation</p> <p>Dr Sunderland's research challenged the accepted view, derived mainly from studies focussing on cycling, that heat acclimation could be best achieved through a programme of sub-maximal, steady state exercise. It grew out of her theoretical and practical understanding that, for heat acclimation protocols to be both effective and efficient, it is essential to create a high body temperature (Sunderland & Tyler, 2005, J Physiol, 565P, pp PC6). It proved her hypothesis that high intensity intermittent acclimation improved games type activity by 33% (Sunderland, Morris & Nevill, 2008, Br J Sports Med, 42, pp 327-333) and enhanced field hockey skill performance (Sunderland, Marwood & Nevill, 2003, J Sports Sci, 21, pp 290).</p> <p>b) Neck cooling</p> <p>Dr Sunderland's research was the first to prove that neck cooling improves running performance in the heat (Tyler, Wild & Sunderland, 2010, Eur J Appl Physiol 110, pp 1063-1074; Tyler & Sunderland, 2011, J Athl Train 46(1), pp 61-68; Tyler & Sunderland, 2011, Med Sci Sports Exerc 43(12), pp 2388-2395). The research in this Unit assessed the effect of the cooling collar on rate of perceived exertion, affect, thermal sensation, and running performance in the heat. Findings indicated that the cooling collar may improve performance, but not necessarily 'feel good', which has important implications for application (Minniti, Tyler & Sunderland. Eur J Sports Sci 11(6), pp 419-429). Previous research had focussed on pre-cooling or non-practical cooling during exercise. Based on her understanding of how the brain regulates exercise performance in the heat, Dr Sunderland hypothesised that cooling the neck region, which has high alliesthesial thermosensitivity, would provide the basis for a practical approach to improving performance. Her hypothesis was proven, leading to the development of a neck-cooling collar, which has been adopted and used by other researchers, attracting media attention worldwide.</p> <p>c) Improving hockey performance</p> <p>Dr Sunderland's research demonstrated that:</p> <ol style="list-style-type: none"> 1) Field hockey skill and decision-making in international hockey players competing in hot environments is diminished with approximately 2% hypohydration. It also proved that if players remain euhydrated hockey performance is maintained (MacLeod & Sunderland, 2012, Scand J Med Sci Sports 22(3), pp 430-438).

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- 2) Hydration status of female international players shows considerable inter-individual variation (MacLeod & Sunderland, 2009, *JSCR* 23(4), pp 1245-1251).
- 3) Hockey umpires cover over 6km during a match, with 2.7% of the time spent running at high-speed, although there is large inter-individual variation (Sunderland et al., 2011, *Eur J Sports Sci* 11(6), pp 411-417).

The Units original research investigating means to improve exercise in the heat has been a driver for other research groups around the world to further investigate acclimation strategies for team sports and neck cooling for physical and cognitive performance in sporting and military populations. Examples for acclimation include researchers from the Australian Institute of Sport (Petersen et al., 2010, *Int J Sports Physiol Perform* 5(4), pp 535-45) and University of Western Australia (Brade et al., 2013, *J Sports Sci* 31(7) pp 779-786) and for neck cooling, groups from the Defence Medical & Environmental Research Institute, Singapore (Lee et al., 2012, *Proc Physiol Soc* 26, PC55) and Hiroshima University, Japan (Hasegawa & Shimizu, 2013, *Proc ECSS*, Barcelona).

3. References to the research (indicative maximum of six references)

MacLeod, H. and Sunderland, C. (2012) Previous-day hypohydration impairs skill performance in elite female field hockey players. *Scandinavian Journal of Medicine and Science in Sports*, **22(3)**, 430-438. DOI: 10.1111/j.1600-0838.2010.01230.x. (Impact factor: 3.2, Ranking 8/84)

Tyler, C.J. and Sunderland, C. (2011) Neck cooling and running performance in the heat: single versus repeated application. *Medicine and Science in Sports and Exercise*, **43(12)**, 2388-2395. DOI: 10.1249/MSS.0b013e318222ef72. (Impact factor: 4.5, Ranking 4/84)

Sunderland, C., Pearce, E., Taylor, E. and Spice, C. (2011) Activity profile and physical demands of male field hockey umpires in international matches. *European Journal of Sports Sciences*, 11(6), 411-417. DOI:10.1080/17461391.2010.536576. (Impact factor: 1.2, Ranking 48/84)

Tyler, C.J., Wild, P. and Sunderland, C. (2010) Practical neck cooling and time-trial running performance in a hot environment. *European Journal of Applied Physiology*, **110**, 1063-1074. DOI 10.1007/s00421-010-1567-7. (Impact factor: 2.7, Ranking 12/84)

Sunderland, C., Morris, J.G. and Nevill, M.E. (2008) A heat acclimation protocol for team sports. *British Journal of Sports Medicine*, **42**, 327-333. DOI:10.1136/bjism.2007.034207. (Impact factor: 3.7, Ranking 6/84)

Sunderland, C., Marwood, S. and Nevill, M. (2003) Effect of heat acclimatization on field hockey skill performance. *Journal of Sports Sciences*, **21**, 290. (Impact factor: 2.1, Ranking 22/84)

4. Details of the impact

a) Heat acclimation

Dr Sunderland's research has changed international protocols and practices and so improved the performance of a wide range of sportsmen and women ranging from international hockey players and elite athletes to school teams and individuals engaged in charity events.

Throughout the REF period, GB Hockey have used Dr Sunderland's acclimation process and sought her advice in preparation for all tournaments in hot environments including the 2008 Beijing Olympic Games. The Head Coach of the British Squad, has commented "We have chosen to use Nottingham Trent for our acclimatisation training because of Dr Sunderland's expertise coupled with the unparalleled facilities...such preparation can mean the difference between winning and losing. We are pleased to be working with a university that offers us the very best personnel and state-of-the-art technology...Dr Sunderland is the leading authority on how to prepare hockey players for hot climates."

Impact case study (REF3b)

Members of the England and Wales Hockey squads also came to NTU to be acclimatised by Dr Sunderland prior to the Commonwealth Games in Delhi in 2010.

Throughout the REF period, others visiting NTU to acclimatise and/or experience exercise in the heat include athletes preparing for the Marathon des Sables and marathon runners preparing to race in hot environments. As the Director of Racekit UK acknowledges, *“Since becoming aware of Dr Sunderland’s research and expertise I have changed not only the way I prepare as an athlete to perform in hot climates, but also the way I prepare my clients to do the same. Dr Sunderland’s acclimation sessions at Nottingham Trent University have become a vital part of our preparation for the Marathon des Sables”*

Prior to the Netball World Championships (2011) international netball players visited NTU to experience Dr Sunderland’s acclimation process. As have a School hockey team preparing to go to Malaysia and a number of individuals preparing for charity runs and walks.

Australian sports scientists have adapted Dr Sunderland’s research, introducing an intermittent acclimation protocol to the Australian cricket team.

The Scottish Institute of Sport first approached Dr Sunderland for advice about how best to acclimate their players ahead of the 2010 Delhi Commonwealth Games, and have continued to seek her advice since then. This has resulted in elite hockey and cricket players and athletes, adopting her new protocol and improving their performance. It also resulted in The Scottish Institute of Sport and GB hockey adopting the protocol and inviting Dr Sunderland to share her experience and expertise (by) working as their Heat Acclimation Consultant.

b) Neck cooling

Because Dr Sunderland was the first to demonstrate that neck cooling improves performance. Her work attracted both research and media attention worldwide. The Field Hockey Coach at Indiana University highlights the value and impact of her work thus, *“Our pre-season is exceptionally hot. By following Dr Sunderland’s very specific recommendations regarding neck cooling and the timing of technique/skill and acclimation sessions, we were able to safely and efficiently make the greatest performance gains ever for the coming season.”*

Articles have appeared in The New York Times (<http://well.blogs.nytimes.com/2011/06/29/lessons-from-exercising-in-the-heat/>), SHAPE magazine and Women’s Health magazines, bringing the benefits of neck cooling to the recreational audience.

c) Improving hockey performance

Dr Sunderland’s research changed and continues to influence the performance of international hockey players and umpires during competitions in hot climates (e.g., Beijing Olympics 2008). The maintenance of hydration status (euhydration rather than hypo- or hyperhydration) is imperative to both physical and skill performance improvement and therefore success. As a result of her work, the monitoring and prescription of fluid specifically during tournaments in hot conditions is now integral at major competitions. The Head Coach Wales Hockey stated, *“Dr Caroline Sunderland provided us with highly effective strategies for training, recovery and nutrition for playing at the Delhi Commonwealth Games. These strategies were essential for maintaining our performance throughout the tournament in such heat.”*

Having been commissioned to assess the activity profile and therefore physical demands of hockey umpiring by England Hockey and by the International Hockey Federation (FIH), Dr Sunderland’s research led to the SHAPE research group producing a training manual in 2010, which is now used by international umpires from around the World. The Officials Manager, The International Hockey Federation, confirms, *“The research undertaken by Dr Caroline Sunderland and her team at Nottingham Trent University into the distances, types and intensities of running that International Umpires perform in individual matches and at Tournaments, led to the creation of the first ever fitness training programme for Umpires. This was drawn up in December 2010 in the*

form of an International Umpire Fitness Training Manual. It is now provided to all International Umpires and is available on the FIH website for all Umpires' use, not just those who perform at elite level... the fitness training programme is a vital component of the standard preparations for Umpires in the run up to their appointments to major FIH World level Tournaments and multi-sports events such as the Olympic Games."

To summarise, Dr Sunderland's research has improved exercise performance in the heat for both elite and recreational athletes across a range of sports. The Head Coach Wales Hockey reflects the value of her work when she states, *"Dr Caroline Sunderland's research has had significant impact across many sports but particularly in elite international hockey. She is the world's leading authority on acclimation for team sports."*

5. Sources to corroborate the impact (indicative maximum of 10 references)

1. Wales Hockey coach. Corroborates the use of The Unit's research by international players and sports scientists in determining the acclimation protocols used prior to competition and the nutrition and cooling strategies used during competition to enhance performance.
2. Director Racekit UK. Corroborates how our research and expertise impacts upon the preparation and performance of recreational as well as elite athlete populations.
3. Hockey Coach, Indiana University, USA. Also corroborates that our research has had significant and far reaching impact.
4. Officials Manager, International Hockey Federation. Corroborates the use of our research for the performance enhancement of international umpires and the development of new policies and procedures from 2010 to today. Also corroborates that our research has had significant and far reaching impact.
5. Press release including comment from the GB Women's Hockey Coach, previously GB Men's hockey coach. Corroborates the completion of acclimation at NTU and provides evidence for our research and expertise being the driver for consulting upon acclimation protocols.
6. Reference and link to the fitness training manual corroborating the dissemination of research and the production of materials for use by the end-user. Sunderland C., Tweddle, M. and Motley, K. (2011) FIH Umpires Fitness Training Manual
<http://www.fih.ch/files/Sport/Umpires/Umpires%20Fitness%20Training%20Manual.pdf>
7. Reference to research that has adapted our acclimation protocol for use with Australian cricket. Petersen CJ, Portus MR, Pyne DB, Dawson BT, Cramer MN, Kellett AD. Partial heat acclimation in cricketers using a 4-day high intensity cycling protocol. Int J Sports Physiol Perform. 2010 Dec;5(4):535-45.
8. Example press coverage of our research. Corroborates the dissemination of our research to a wide-ranging audience. <http://news.bbc.co.uk/1/hi/health/7547937.stm>
9. Reference to research that has employed neck cooling to assess cognitive function in military personnel. Corroborates the use of our research in populations as well as sporting and the influence of our research in the field. Lee, J.K., Lui, G., Fan, P., Tan, Y., Tey, F., and Law, L. (2012) Effects of exercise-induced hyperthermia and neck cooling on cognitive performance. Proc Physiol Soc 26, PC55.