Institution: University of Northumbria at Newcastle

Unit of Assessment: 24 (Sport and Exercise Sciences, Leisure and Tourism)

Title of case study: Supporting elite athletes by improving use of cryotherapy in recovery

Period when the underpinning research was undertaken: 2012 – 2020

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:
Stuart Goodall	Senior Lecturer / Associate Professor	01/02/2011 - present
Glyn Howatson	Professor	01/09/2009 - present
Kirsty Hicks	Senior Lecturer	01/02/2016 - present

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 (indicative maximum 100 words)

Cold water immersion (CWI), a form of cryotherapy, is routinely deployed after competition and other strenuous exercise to accelerate athletes' recovery and provide a competitive edge. The English Institute of Sport (EIS) provides science and medicine support services to the British Olympic and Paralympic sports teams. Research from the University of Northumbria shaped the development of cryotherapy guidelines for the EIS. These guidelines formed the basis of training developed for EIS practitioners and physiotherapists who work with elite athletes. In the lead-up to and throughout the 2016 Rio Olympics, advice was adopted by the British Olympic Association, and the new guidelines were used by athletes across 23 Team GB sports to enhance recovery. Since then, additional research has led to the innovative application of phase change material (PCM) enabling more athletes to use cryotherapy, more often, and with greater benefits. [text removed for publication]

2. Underpinning research (indicative maximum 500 words)

Practitioners working with elite athletes continually strive to identify methods to optimise recovery from strenuous exercise. Such methods are of utmost importance in competition scenarios where time for recovery is limited. Cryotherapy interventions use cooling techniques, traditionally in the form of cold water immersions (CWI), to facilitate athletic recovery from strenuous exercise. CWI had been widely used within professional sport before 2012, when a systematic review was conducted by Northumbria's *Optimising Human Performance* research group. This research showed there were no clear protocols establishing the most effective application of CWI [**R1**]. The existing research was descriptive in nature and did not explain the mechanisms underpinning the effectiveness of CWI. Given that faster recovery provides athletes with a competitive edge, the development of detailed protocols to improve up-take and administration of CWI was of paramount importance.

In collaboration with practitioners and the science and medicine leads within the English Institute of Sport (EIS; Jonathan Leeder and Ken van Someren), researchers from the University of Northumbria investigated how CWI affected the physiological stress experienced by athletes during a simulated tournament scenario [**R2**]. Markers of recovery, including sprint performance, muscle function, biochemical markers of damage, and oxidative stress were assessed with participants over five days. This work confirmed that using CWI resulted in an improved performance 24 hours after exercise; in particular, improvements in sprint ability and decreases in the production of creatine kinase (a biochemical marker of damage) were observed [**R2**]. This collective body of research formed the basis for detailed CWI protocols outlining optimal duration, temperature, timing, depth, and exposures to achieve optimal athletic recovery.

The benefits of CWI are well understood by practitioners and athletes, although there are barriers to using this treatment, including: tolerance levels of the athletes, requirements of facilities (access to power, space, water supply etc.), numbers of athletes who can use the facilities at any one time, limited availability at competition sites, and the extended time spent in the facility completing the therapy. These limitations reduce the opportunity for optimal recovery and leave athletes underprepared. As a result, Northumbria's research group investigated the use of phase change material (PCM) as an alternative cryotherapy strategy, in collaboration with practitioners at the Nicholas Institute of Sports Medicine and Athletic Trauma (NISMAT; Susan Kwiecien and Malachy McHugh).

PCM modules resemble ice packs, but the material contained within them can be altered to deliver different freeze-thaw temperatures for extended periods. These packs can be inserted into clothing and worn by athletes for prolonged cooling periods to facilitate recovery via focused, topical application. As the whole body is not immersed, this can be tolerated by athletes for longer periods. In the first study of its kind, Northumbria's research showed that, thanks to prolonged periods of cooling (3-6 hours instead of ~15 minutes of CWI), PCM was effective at accelerating recovery [**R3**]. Importantly, the application of PCM elicits a comparable reduction in intramuscular temperature to CWI (~4°C at 1 cm and ~6°C 3 cm depth of muscle), but the extended exposure time that is possible with PCM allows for a sustained, lower muscle temperature [**R4**]. An additional benefit of using PCM over CWI is that many athletes can be treated at the same time, thus providing significant added value in terms of improved efficiency, time, and space management. The PCM intervention has also shown efficacy in applied contexts using athletes from professional soccer [**R5**] and baseball [**R6**]. Both studies reported that strength loss and symptoms of muscle soreness were significantly attenuated compared to placebo, 2 to 3 days after competition.

The two strands of Northumbria's research into cryotherapy (development of CWI protocols and novel application of PCM) for athletic recovery have been instrumental in [text removed for publication].

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

R1. *Leeder, J., **Gissane, C., *van Someren, K. **Gregson, W., and **Glyn Howatson** (**2012**) 'Cold water immersion and recovery from strenuous exercise' *British Journal of Sports Medicine*, **46**: 233-240 http://dx.doi.org/10.1136/bjsports-2011-090061

R2. *Leeder, J., Godfrey, M., Gibbon, D., **Gaze, D., **Davison, G., *van Someren, K., and **Glyn Howatson** (**2019**) 'Cold water immersion improves recovery of sprint speed following a simulated tournament' *European Journal of Sport Science* **19**: 1166-1174 https://doi.org/10.1080/17461391.2019.1585478

R3. *Kwiecien, S., *McHugh, M., and **Glyn Howatson** (**2018**) 'The efficacy of cooling with phase change material for the treatment of exercise-induced muscle damage: pilot study' *Journal of Sport Science* **36**: 407-413 https://doi.org/10.1080/02640414.2017.1312492

R4. *Kwiecien, S., *McHugh, M., **Stuart Goodall.**, **Kirsty Hicks.**, **Hunter, A., and **Glyn Howatson** (**2019**) 'Exploring the efficacy of a safe cryotherapy alternative: physiological temperature changes from Cold Water Immersion vs Phase Change Material cooling' *International Journal of Sports Physiology and Performance* **14**: 1288-1296 https://doi.org/10.1123/ijspp.2018-0763

R5. Clifford, T., **Abbott, W., *Kwiecien, S., **Glyn Howatson**, and *McHugh, M. (**2018**) 'Cryotherapy re-invented: application of phase change material for recovery in elite soccer' *International Journal of Sports Physiology and Performance* **13**: 584-589 https://doi.org/10.1123/ijspp.2017-0334

R6. **Mullaney, M., *McHugh., *Kwiecien, S., **Ioviero, N., **Fink, A., and **Glyn Howatson** (**2021**, published on the 1st January 2021, first available online 15th July 2020) 'Accelerated muscle recovery in baseball pitchers using Phase Change Material cooling' *Medicine & Science in Sports & Exercise* https://doi.org/10.1249/mss.0000000000002447

***Co-authors include practitioner-researchers:** J. Leeder, EIS practitioner, part-time doctoral student at Northumbria (2012-2017). S. Kwiecien, NISMAT practitioner, part-time doctoral student at Northumbria (2016-2020). M. McHugh from NISMAT is a Visiting Professor and Ken van Someren from EIS was a Visiting Professor.

****External university collaborators:**
C. Gissane, St Mary's University College: provided expertise into meta-analytics.
W. Gregson, Liverpool John Moores University: provided insights into study application.
D. Gaze, University of Westminster: provided expertise on blood analysis of some variables.
G. Davison, Ulster University: provided expertise on blood analysis of some variables.
A. Hunter, University of Stirling: provided training and supervision of muscle temperature.
W. Abbott, Brighton and Hove Albion FC: access to participants and data collection.
M. Mullaney, Mullaney & Associates Physical Therapy (USA), administered treatments.
N. Ioviero, Kean University (USA): provided access to participant and data collection.
A. Fink, Mullaney & Associates Physical Therapy (USA), administered treatments.

4. Details of the impact (indicative maximum 750 words)

The EIS works with elite sport athletes, most notably the Olympic and Paralympic teams, to provide access to leading-edge technology, engineering, and new research in science and medicine that help athletes improve their performance. Known as the 'team behind the team', the EIS was awarded GBP67,400,000 by UK Sport for the Tokyo Olympic games cycle. The EIS Performance Innovation team aims to ensure that Britain's top athletes are among the most prepared and best equipped on the world stage [**E1**]. Since 2013, Northumbria research has supported EIS work to ensure optimum performance in three main ways: (1) providing protocols and guidelines for practitioners delivering cryotherapy for athletes, (2) providing advice to athletes, coaches, and practitioners directly, including at the Rio Olympics, and (3) by using research to develop and test an improved cryotherapy intervention that has been used by athletes at international competitions and in preparation for the Tokyo Olympics.

4.1 Protocols and guidelines for cryotherapy treatment
In collaboration with the EIS [**E2**], Northumbria's *Optimising Human Performance* research group developed evidence-based protocols for the practical application of CWI. Previously, CWI was frequently used by elite athletes without clear guidelines. Northumbria's protocols drew on the body of research to clarify *when* and *when not* to use the intervention, and provided athletes with guidelines on the duration, timing, temperature, water depth, and number of exposures that would achieve the most optimal recovery [**E3**, p5]. The EIS took forward these findings by sharing them directly with support staff in Olympic and Paralympic teams [**E1**]. Additionally, Professor Howatson delivered training on the guidelines at CPD events for EIS specialist exercise science and medicine practitioners, and those from all national support institutes (Sport Scotland, Wales, and Ireland) [**E1**]. The new protocols were disseminated among [text removed for publication] enabling them to '*practically apply the knowledge'* [**E1**].

'Absorb' is an online information platform for EIS physiotherapists and doctors. Knowledge is categorised into key module areas covering a range of recommended interventions. Physiotherapy is a broad-ranging discipline and accounts for more than 70 employees at EIS, many of whom travel with sports for anything up to 120 days a year. Some practitioners are based in relatively remote locations and experience levels vary significantly. 'Absorb' enables them all to access the same standards of treatment protocols ('Absorb' website). In addition, 'Absorb' forms an important part of the induction programme for all new EIS starters [**E1**]. Technical content based on Northumbria research focussing on best practice for recovery has been delivered via 'Absorb' since its launch in 2017. To date, the recovery content has been

accessed by more than 60 EIS physiotherapists [**E1**], upskilling the new cohort of specialists by providing clear protocols on how to use cryotherapy for recovery.

4.2 Advice on recovery for Team GB athletes

The EIS provides support directly to athletes via an app which enables them to record their daily training and wellness, as well as storing medical records. In 2015, the EIS condensed Northumbria's cryotherapy research into bite-size chunks and developed a new 'Recovery Tips' section for the app. The app allowed athletes to easily access the state-of-the-art and best practice guidelines on recovery [see Figure 1 within **E1**]. The content of these 'Recovery Tips' was underpinned by research from Northumbria [**E1**]. In the build-up to Rio 2016, 'Recovery Tips' was trialled by [text removed for publication]. During the trial, 'Recovery Tips' was used by more than 80 athletes, who actively engaged with the content more than 1,200 times [**E1**]. As a result of this successful trial, 'Recovery Tips' was adopted by the British Olympic Association, which has responsibility for athletes during the Olympics. Thus, the information was used by athletes across the 23 sports for which Team GB submitted athletes, in order to achieve effective recovery and aid performance during Rio 2016. During BBC Sport coverage of Rio 2016, six-time Olympic gold medallist Sir Chris Hoy explained that in-depth knowledge of how and when to apply CWI is required to enhance recovery. Hoy added that this sector-leading expertise came from (Northumbria-led research collaborator) [**R1**, **R2**] Jonathan Leeder [**E4**].

4.3 Increasing access to, and benefits of, cryotherapy for elite athletes

Traditional cryotherapy has known benefits, but it also presents logistical challenges, particularly when athletes are travelling for competitions as it requires static periods of immersion at low temperatures. In 2017, Northumbria introduced a novel cryotherapy intervention (PCM) to the EIS, as a way of circumventing the logistical issues associated with CWI, and concurrently increasing the time for cooling [**E5**]. PCM modules are compact and easily transportable, cool quickly, and can be simultaneously used with whole squads for periods of up to six hours, facilitating recovery even while athletes are on-the-go (e.g., when travelling between competition and training venues) [**R5**].

The benefits for recovery derived from Northumbria's research were clear to EIS and so they worked with Northumbria [text removed for publication]. Athletes provided positive feedback on the intervention [**E6**]. Following these positive trials, athletes from six Olympic sports [text removed for publication] have adopted PCM for use in preparing for, and during, the Tokyo Olympics [**E6**].

In addition, EIS has implemented the PCM intervention as standard practice: *'each of the five main EIS hub sites across the country [have] been equipped with PCM* [text removed for publication] *to augment recovery'* [**E6**]. Due to high tolerability by athletes, these are applied beyond original recovery interventions for injury management. This strategy has enabled the five Technical Lead Physiotherapists across each region to implement PCM for the management of injury in elite athlete populations [**E6**]. [text removed for publication] stated that: *'[Northumbria's] investigations have instilled confidence to coaches, athletes and support staff that the PCM … had real potential to enhance recovery between repeated bouts of training and international competition leading up to and including the Tokyo Olympics. This work was essential in enabling the EIS to take the project forward from just an idea to implementation with athletes'* [**E6**].

The exceptional degree of applied science used to take a team to compete at the highest level means it is difficult to unpick the role of any one tool in achieving success, however, some practitioners supporting elite athletes have seen clear beneficial outcomes of using PCM to accelerate athlete recovery. For example, [text removed for publication] explained how PCM contributed to [text removed for publication] success in [text removed for publication]: *'*[text removed for publication] *didn't tolerate traditional CWI particularly well … We were able to use the phase change material as part of our global recovery strategy and* [text removed for publication] *was able to tolerate this strategy really well. I believe this intervention was an important component, it allowed* [text removed for publication] *to recover between each qualification* [text removed for publication] *and between events'* [**E7**].

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

Ref.	Source of corroboration	Link to claimed impact
E1	Testimonial - [text removed for publication]	Corroborating use of Northumbria's research [text removed for publication]
E2	Document: Memorandum of Understanding	Confirming the agreement of EIS and Northumbria to collaborate towards enhancing Great Britain's future Olympic and Paralympic medal prospects
E3	Document: BASES resources: Expert Statement on Athletic Recovery Strategies (2016) and recording of the 2016 BASES conference	Evidence of the development and dissemination of cryotherapy protocols among elite practitioners and athletes
E4	Document: transcript of video footage of Chris Hoy during the BBC coverage of Rio 2016	Shows enhanced understanding of when and when not to use CWI interventions (developed by Northumbria) among athletes and wider Olympic community
E5	Document: [text removed for publication]	[text removed for publication]
E6	Testimonial - [text removed for publication]	[text removed for publication]
E7	Testimonial - [text removed for publication]	[text removed for publication]