

<p>Institution: Loughborough University</p>
<p>Unit of Assessment: C26 Sport and Exercise Sciences, Leisure and Tourism</p>
<p>Title of case study: Improving Paralympic athletes performance: Optimising wheelchair configurations and enhancing training strategies</p>
<p>1. Summary of the impact (indicative maximum 100 words)</p> <p>This well established research conducted by members of Peter Harrison Centre for Disability Sport (Loughborough University) is seen as an integral part of the support provided for Paralympic wheelchair athletes and has impact in 3 key areas:</p> <ol style="list-style-type: none"> 1. To help identify the fundamental characteristics of elite wheelchair athletes and assist with athlete profiling by supporting the Paralympic ‘performance pathways’ to refine their talent identification and confirmation procedures 2. With the refinement of the testing and monitoring procedures used to assess the physiological and biomechanical demands of wheelchair sport performance 3. Supporting the education of high-performance coaches by enabling them to gain a better understanding of the technical variables that affect wheelchair mobility performance
<p>2. Underpinning research (indicative maximum 500 words)</p> <p>In 2005, Loughborough University (LU) made a commitment to ‘disability sciences research’. This was cemented and advanced via an initial £746,000 grant by the Peter Harrison Foundation (PHF) for the establishment of the Peter Harrison Centre for Disability Sport (PHC) (2004-10). The underpinning research that is relevant to generating impact began in 2008 and was led by Dr Vicky Goosey-Tolfrey who was appointed as Senior Lecturer & Director of the PHC in 2007 at LU, and was promoted in 2011 to Reader in Applied Disability Sport. It also involved three PhD students, one of which was funded by UK Sport in partnership with ParalympicsGB all who now hold post-doctoral positions (Dr’s Barry Mason, Christof Leicht and John Lenton; 2011-present).</p> <p>The research also grew out of an International collaboration with Prof. Lucas van der Woude (Chair in Human Movement, Rehabilitation and Functional Recovery at the University Medical Center Groningen). The work enabled the PHC to bridge the divide between rehabilitation sciences and a high performance sporting environment where LU’s expertise lies by sharing knowledge across the exercise continuum. Due to the complexity of wheelchair propulsion it is unclear how the daily-ambulation research translates to a sporting context. The experimental studies have confirmed that during sub-maximal wheelchair propulsion the use of larger camber settings (20° and 24°) increased the power output (P_O) requirements of the wheelchair sportsperson [3.1]. During sub-maximal propulsion P_O increments are unfavorable due to the associated increases in physiological demand. Given the fact that smaller wheels (24”) also increase the physiological demands the group were able to conclude that the selection of both these configurations should be avoided in the same wheelchair to prevent these elements becoming exacerbated and thus performance hampered [3.2]. The use of an instrumented hand-rim (SMART^{Wheel}) was a novel and innovative approach into the ergonomics of wheelchair configuration. It has never been adopted before in sports wheelchairs with the relevant sports specific range of configurations. Yet, it enabled a more detailed investigation into the ergonomics of sports wheelchair performance evoked by changes in wheel size [3.3].</p> <p>The laboratory based investigations that are conducted in the PHC’s state-of-the-art facilities use a specialised treadmill which enable the researchers to investigate the biomechanical and physiological responses of sports wheelchair propulsion. Using this ecologically valid approach, ensuring that the wheelchair athlete is tested in their own sports wheelchair the group have extended their research strategy to challenge the use of able-bodied exercise/training paradigms and their application to the wheelchair athlete. Research at LU has established that the ratings of perceived exertion (RPE) can be utilised for the regulation of hand-cycling exercise for trained paraplegics [3.4]. Moreover, despite the blunted heart rate response that is experienced by persons with tetraplegia during exercise, the researchers have shown that RPE can also be used</p>

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by trained wheelchair rugby players to regulate their training. This line of enquiry and partnerships with UK Sport secured a grant extension of £1,300,000 from the PHF (2011-18). The PHC research theme has recently been extended to examine the immunological, physiological, hormonal and metabolic aspects of disability sports performance with the additional expertise of Dr Lettie Bishop (Senior Lecturer; 2000-13) **[3.5, 3.6]**.

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

Dr Goosey-Tolfrey's recognition and impact in the field has been facilitated by her publications in high-quality peer-reviewed journals such as *Medicine & Science in Sports & Exercise* which is ranked 3/84 of the Sports Sciences journals. Further evidence of quality is that the research was novel and externally funded. This research has focused on two complementary themes of (i) optimising wheelchair configuration and (ii) enhancing training strategies.

Research Output

(i)

- 3.1. **Mason, B.S**, Woude, van der L.H.V., de Groot, S. & **Goosey-Tolfrey, V.L.** (2011). The effects of camber on the ergonomics of propulsion in wheelchair athletes. *Medicine and Science in Sports and Exercise*. 43(2), 319-326. doi: 10.1249/MSS.0b013e3181edf973. [Impact Factor = 4.431]
- 3.2. **Mason, B.S**, Woude, van der L.H.V., **Tolfrey, K.**, **Lenton, J.P.** & **Goosey-Tolfrey, V.L.** (2012). Effects of wheel and hand-rim size on sub-maximal propulsion in wheelchair athletes. *Medicine and Science in Sports and Exercise*. 44(1), 126-134. doi: 10.1249/MSS.0b013e31822a2df0. [Impact Factor = 4.431]
- 3.3. **Mason, B.S**, Woude, van der L.H. and **Goosey-Tolfrey, V.L.** (2013). The ergonomics of wheelchair configuration for optimal performance in the wheelchair court sports. *Sports Medicine*. 43(1), 23-38. doi: 10.1007/s40279-012-0005-x. [Impact Factor = 5.155]

(ii)

- 3.4. **Goosey-Tolfrey, V.L.**, **Lenton, J.P.**, Goddard, J, Oldfield, V, **Tolfrey, K** & **Eston, R.** (2010). Regulating intensity using perceived exertion in spinal cord injured participants. *Medicine and Science in Sports and Exercise*. 42(3), 608-613. doi: 10.1249/MSS.0b013e3181b72cbc. [Impact Factor = 4.431]
- 3.5. **Leicht, C.**, **Bishop, N.C** & **Goosey-Tolfrey, V.L.** (2011). Mucosal immune responses to treadmill exercise in elite wheelchair athletes. *Medicine and Science in Sports and Exercise*. 43(8), 1414-1421. doi: 10.1249/MSS.0b013e31820ac959. [Impact factor = 4.431]
- 3.6. **Leicht, C.**, **Bishop, N.C.**, & **Goosey-Tolfrey, V.L.** (2012). Mucosal immune responses during court training in elite tetraplegic athletes. *Spinal Cord*. **50(10), 760-765**. doi:10.1038/sc.2012.47. [Impact factor = 1.805]

Note. Loughborough University staff are highlighted in **bold**

Research/ Knowledge Transfer Grants that Supported this Research Programme

- UKSport Graduate Innovation Programme Studentship with the British Paralympic Association: The Ergonomics of Wheelchair Configuration for Optimal Sports Performance. Principle Investigator: **Dr Vicky Goosey-Tolfrey** (Loughborough University) with Co-investigator: Prof. Lucas van der Woude (University of Groningen, The Netherlands). (£100,000; 2007-2010).
- iNet: The effects of specific respiratory warm-up on the physical capacity and exertional dyspnea of persons with a spinal cord injury. Principal Investigator: **Dr Vicky Goosey-Tolfrey** (Loughborough University) with Co-investigators: Dr Graham Sharpe (Nottingham Trent University) and Dr Paul Smith (Cardiff University). (£26,069; 2009-2010).
- The Peter Harrison Foundation. The Peter Harrison Centre for Disability Sport – Research Centre Core Funding (inc. Research Associates). Principle Investigator: **Dr Vicky Goosey-Tolfrey** (Loughborough University) with Co-investigator: **Prof. Stuart Biddle** (Loughborough

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University). (£1,300,000; 2011-2018).

- UK Sport: The application of wheelchair ergonomics for optimal wheelchair performance. **Dr Vicky Goosey-Tolfrey and Dr Barry Mason** (Loughborough University). (£5,000; 2011-2012).
- Knowledge Transfer Grant: Practical Guidelines for Wheelchair Selection in Court Sports. **Dr Vicky Goosey-Tolfrey and Dr Barry Mason** (Loughborough University). (£2,100; 2011).
- UKSport - An applied review of the physiological determinants of performance in upper body exercise in athletes with a disability. **Dr Vicky Goosey-Tolfrey** (Loughborough University). (£3,000; 2011).
- EPSRC: Assistive technology for wheelchair sports. **Dr Vicky Goosey-Tolfrey and Dr Barry Mason** (Loughborough University). (£18,600; 2011-2012).
- British Paralympic Association: Funding a UK High Performance Conference for Paralympic Sports Science and Sports Medicine. The theme of the conference “The Road to Rio: Learning from London”, to disseminate and share key lessons learned from across sports and disciplines as we prepare for the Sochi 2014 and Rio 2016 Paralympic Games. **Dr Vicky Goosey-Tolfrey** (Loughborough University). (£40,000; 2013).

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

The evidence of the research impact is wide and significant. It has been evidenced by a) advancing assistive technologies in a sporting environment; b) having peer-reviewed knowledge; c) being of an applied nature with out-reach to athletes, coaches and wheelchair manufacturers and d) has instigated collaborative networks with several key internationally renowned researchers. The PHC's research (2008-13) has delivered on a number of performance related projects which have impacted on UK Sports funded Paralympic Sports and contributed to ParalympicGB's achievements at the London 2012 Paralympics [5.1, 5.2].

Supporting Paralympic Performance: The outputs from the PHC's wheelchair configuration research theme has significantly influenced the preparation strategies of the Paralympic athletes leading into the 2012 London Paralympic Games, by better educating them about wheelchair configuration and chair choice (all members of the wheelchair rugby and basketball teams, n=36). The research findings have been presented by Dr's Goosey-Tolfrey and Mason to ParalympicsGB practitioners and both GB athletes/coaches. The LU based research found that changes in wheelchair camber greatly influenced wheelchair mobility performance. With Dr's Goosey-Tolfrey and Mason's assistance they worked closely with UK Sport's Research and Innovation team on individual case studies to optimise straight line speed and agility within the sport of wheelchair rugby. Working with the rugby athletes on an individual basis provided them with the evidence-base to help inform their choice when purchasing sports wheelchairs for London 2012. Consequently, two of the twelve players reduced their chair camber following this work [5.3]. Furthermore, one of the central projects in LU's partnership with UK Sport was identified from the earlier work of Dr Barry Mason's PhD, where the need to individualise the wheelchair-user-interface was identified. This led to a joint partnership between UK Sport, BMW and LU (including the Sports Technology Institute (2011-12)) where a systematic ergonomic approach was adopted to improve the design of wheelchair seating. This team developed individualised seating for 8 players (4 men and 4 women) competing in the Paralympic Games in London 2012 [5.4]. At the other end of the sporting spectrum, the key insights from this work have advised athletes, particularly those who are new to wheelchair sport or inexperienced, to configure their sports wheelchairs to 18° camber and 26" wheels.

The LU based research has facilitated the development of on-court wheelchair sport specific procedures, a pool of normative physiological data and training guidelines that can and have been used by sport science practitioners within the Home Institutes (English Institute of Sport (EIS)) and National Governing Bodies. Moreover, a presentation has been made by Dr's Leicht and Goosey-Tolfrey to the UK Sport talent team entitled 'The physiological determinants of performance in upper body exercise in athletes with a disability' to inform the talent scientists of the disability

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pathways. Similarly, the PHC's work has been cited within the guidelines for preparing the Paralympic athlete and practitioner for the 2012 London Paralympic Games that was circulated to all GB staff and athletes at the Games (~600). With Dr Goosey-Tolfrey's assistance novel training strategies have been identified for those practitioners working in disability sport enabling them 'To deliver the best prepared Paralympics team to the Paralympic Games' (achieving the strategic objective of the British Paralympic Association) [5.1, 5.5].

The PHC's research agenda has helped inform the talent identification for British Disability Cycling/ British Para-triathlon, identifying credible performance for Goalball and assisted the applied research that has been provided to the British Wheelchair Basketball Association and Great Britain Wheelchair Rugby. LU's research has helped with the development of heart rate (HR) guidelines for GB wheelchair athletes during training and with the quantification of exercise intensity through the use of rating of perceived exertion (RPE) methods. For example, individualised HR training methods have been established by testing at LU, and consequently been used by several of the GB wheelchair basketball players whilst they were overseas in Europe to support their training (2011) [5.6].

Education and Knowledge Transfer: The PHC is recognised as a leading Paralympic research centre and proof of this positioning was the invitation to lead and organise the 2013 UK High Performance Conference for Paralympic Sports Science and Sports Medicine (with the British Paralympic Association and EIS) funded by the PHF. Moreover, at the other end of the exercise continuum, the key studies cited earlier [3.1, 3.2 & 3.3] underpin sections of a 20 page booklet (which was developed with Bromakin and RGK wheelchair manufacturers and ParalympicsGB). This information is essential as it guides rehabilitation specialists and those involved with development athletes through the journey of wheelchair sports chair selection from beginner to elite performer [5.7].

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

The following sources of corroboration can be made available at request:

Media Coverage

Dr Goosey-Tolfrey's research was given extensive media attention in 2010 on the Channel 4's Paralympic documentaries. Work undertaken in the physiology laboratories at Loughborough University were aired on Channel 4 ((1) Incredible Athletes (60 mins) and (2) Freaks of Nature (30 mins)).

- 5.1. Letter from the Chair and Chief Executive at UK Sport, UK Sport, 40 Bernard Street, London. WC1N 1ST.
- 5.2. Letter from the Deputy Director and Research and Innovation Coordinator, English Institute of Sport.
- 5.3. UK Sport Webpages <http://www.uk sport.gov.uk/sport/summer/wheelchair-rugby>
- 5.4. Quote from Paralympic athlete as see in Webpages about the new sports wheelchair and faster speed as assisted by members of the PHC
<http://www.dailymail.co.uk/sciencetech/article-2198013/Paralympics-2012-How-technology-transforming-Games.html>
- 5.5. Letter from the Director of Sport, ParalympicsGB, British Paralympic Association, 60 Charlotte Street, London. W1T 2NU.
- 5.6. Letter from the English Institute of Sport Strength and Conditioning practitioner.
- 5.7. Letter from RGK Wheelchairs.