**Institution:** Anglia Ruskin University

**Unit of Assessment:** 5 Biological Sciences

**Title of case study:**

Biomechanical and mechanical assessment of equestrian arena surfaces for the London 2012 Olympic Games - the need for new industry standards

**1. Summary of the impact** (indicative maximum 100 words)

The research led to the development of a suite of tests to ensure appropriate assessment of biomechanical, mechanical and physical properties of equestrian arena surfaces. Test arenas were assessed in preparation for the London 2012 Olympic Games, generating data which contributed to changes in the design, construction and management of the Olympic equestrian arenas at Greenwich Park. Subsequently, functional properties suggested as most relevant to the performance, safety and welfare of horses in disciplines such as dressage and show jumping have been described in a White Paper, now endorsed and approved for publication by the Fédération Equestre Internationale (FEI).

**NOTE:** The FEI, established in 1921, is the international governing body responsible for all international equestrian events in disciplines such as dressage, show jumping and eventing. The FEI sets out the regulations for international equestrian competitions, including the Olympics and Paralympics.

**2. Underpinning research** (indicative maximum 500 words)

Our team, RACES (Research and Consultancy in Equine Surfaces) was established in 2010, in partnership with researchers from UCLan and Myerscough College; Northrop (Senior Lecturer, 2010-present) is the key Anglia Ruskin University researcher within the team. RACES is part of a larger collaborative group conducting research into equestrian arena surfaces, working with Professor Mick Peterson at the University of Maine, Dr Rachel Murray at The Animal Health Trust, UK, and Professor Lars Roepstorff at the Swedish University of Agricultural Sciences.

Within the academic community, there has been increased interest in the development and standardisation of research methods to assess the condition of both racetracks and equestrian arenas, with the expectation of improving the welfare of horses by reducing risk of injury, whilst supporting optimal performance of competition horses. Despite this interest, there are as yet no official requirements or approved guidelines for the preparation of equestrian arenas for the sector. Initial work was carried out by RACES from 2010 onwards, with the aim of developing a suite of tests to assess equestrian arenas which could form a basis for such guidelines.

Previous work done elsewhere in the RACES partnership had identified significant temporal and spatial changes in the mechanical behaviour of dressage arenas, and had highlighted the need for greater understanding of the biomechanics of the horse subsequent to small alterations in equine arena surface properties. We took this forward, working on arena surfaces in the context of show jumping, employing a validated contact mat and hoof reference marker (Hobbs *et al*., 2010) to identify the impact of limb landing. Kinematic analysis assessed horizontal hoof displacement on jump landing, using surfaces made up of two distinct sand and fibre compositions. The results identified that small changes in surface composition significantly influenced horizontal hoof displacement and consistency in hoof slip (Orlande *et al*., 2012), suggesting that surface composition affects uniformity of a surface; this has previously been reported by other authors in relation to racing surfaces. Uniformity is of considerable significance because it has been implicated in orthopaedic injury; an arena surface, therefore, should be sampled appropriately to test for spatial differences.

Recent 3D biomechanical analysis has reported effects of surface preparation (harrowing and

rolling) on distal limb kinematics in horses in walk, trot and canter (Northrop *et al*., 2013). There were no differences in hoof rotation or hoof displacement between surface preparations; however, greater metacarpophalageal joint (fetlock) extension at midstance and third metacarpus (cannon) adduction at impact was found after harrowing the surface. Small changes in the surface cushion therefore affect the locomotor responses of the horse; this provides evidence that preparation as well as surface composition and consistency should be considered when assessing an arena surface.

Mechanical tests modified from other sports surfaces and used to assess equestrian surfaces (Orlande *et al*., 2012; Northrop *et al*., 2013) have been beneficial to some extent. It is apparent, however, that these existing devices are unable to detect changes in the lower levels of a surface partly because their mass is too low to be indicative of a horse landing on a surface. Our team, as part of the RACES partnership , has built a biomechanical surface tester (BST) on dual axis rails that mimics a horse's forelimb landing on a surface in canter.

The BST was initially developed by Professor Mick Peterson from the University of Maine, who has shared the design with RACES. The BST was originally described by Peterson *et al*. (2008), and can be used to assess a variety of parameters such as peak load, vertical deceleration, hysteresis and range of horizontal acceleration on impact with a surface, but his prime employment of it was testing equestrian racetrack surfaces. Our team was the first to apply it to test equestrian competition arenas.

Additional work (Holt *et al*., submitted to *Procedia Engineering*) has been carried out using controlled test chambers in order to investigate how differences in surface composition, moisture and density influence measurements taken by the BST. Findings from this work suggested that a sand fibre surface with a polymer binder of medium density and high moisture content most appropriately supported high peak loads, low hysteresis and maximal vertical deceleration.

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

**Northrop, A J.**, Dagg, L-A., Martin, J H., Brigden, C, Owen, A G., Blundell, E. Peterson, M L. and Hobbs, S. J. (2013) The effect of two preparation procedures on an equine arena surface in relation to motion of the hoof and metacarpophalangeal joint. *The Veterinary Journal* DOI: 10.1016/j.tvjl.2013.09.048

Orlande, O., Hobbs, S. J., Martin, J. H., Owen, A. G. and **Northrop, A. J**. (2012) Measuring hoof slip of the leading limb on jump landing over two different equine arena surfaces. *Comparative Exercise Physiology*, 8 (1): 33-39. DOI: 10.3920/CEP11011

Hobbs, S. J., Orlande, O., Edmundson, C. J., **Northrop, A. J**. and Martin, J. H. (2010) Development of a method to identify foot strike on an arena surface: Application to jump landing. *Comparative Exercise Physiology* 7:19-25. DOI: 10.1017/S1755254010000097

These references are papers published in internationally recognised journals that have a rigorous peer-review process. Researchers from this impact statement are shown in bold.

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

There are currently no internationally approved guidelines or standardised methods of assessing an equestrian surface. The absence of recommendations was highlighted in preparation for the equestrian events at the London 2012 Olympic Games due to the arenas being constructed on a raised platform, unprecedented for equestrian activities. Part of our research work informed decisions made by the surface providers (Andrews Bowen Ltd, EPG Ltd and SEL Environmental Ltd) [4, 5] for the construction and preparation of the equestrian surfaces at Greenwich Park for the London 2012 Olympic Games.

The RACES team was subsequently awarded a Research Council UK bronze Podium Award for

'*exceptional research contribution to the London 2012 Olympic and Paralympic Games*' [6].

Subsequent work after the Olympic Games in 2012, and in the first half of 2013, contributed further to raising awareness within the equine sector of the need for recognised standards for equestrian arena surfaces. This work has resulted in the production of a White Paper for the FEI, the worldwide controlling body for all equestrian competitions, including the Olympics. This White Paper reviews current knowledge in this field; describes standardised tests appropriate for assessing equestrian surfaces, and defines key terms that encompass surface functional properties and are intended for use by the equestrian public. This report has now been approved for publication by the FEI [1, 2, 3].

Two areas of impact are described; firstly, changes to the design, construction, preparation and management of the equestrian arena surfaces for the London 2012 Olympic Games, and secondly, increased awareness in the equine sector of the need for industry standards for equestrian arena surfaces. With the endorsement of the White Paper by the FEI, RACES will now work with industry partners such as equine arena surface providers towards sector-wide adoption of the guidelines.

i) London 2012 Olympic Games – equestrian arena surfaces at Greenwich Park

The RACES partnership carried out a series of assessments on a variety of equestrian arenas during 2010 and 2011, in order to advise the surface providers for the London 2012 Olympic Games [1, 4, 6]. A test event was held in June 2011 at the venue site at Greenwich Park [4]. We were involved in assessing and comparing arena surface data for Greenwich, in relation to established competition arenas not constructed on a raised platform. The results from the BST suggested that there were issues that needed to be resolved in relation to the platform construction and water management system. Additionally there were some differences in surface parameters when comparing data taken directly on and off struts (struts were used to support the platform). The decision was made to set up a small test platform (away from Greenwich Park) that we assessed regularly from November 2011 until March 2012. The issues were resolved by increasing stiffness of the base layer of the arena, and minor modifications were subsequently made in surface composition and management. The alterations resulted in a more favourable load carrying capacity and also minimised the differences found on and off struts.

RACES were involved in the decision making for the arena surface, and carried out final tests at Greenwich Park two weeks prior to the equestrian events at London 2012, to ensure surface properties were appropriate [1, 4, 6]. The Environmental Protection Group Ltd (EPG), the contractor appointed by LOCOG (the London Organising Committee of the Olympic Games) for the work at Greenwich Park, has confirmed that our research work informed decisions made by the surface providers, and was instrumental in gaining approval from LOCOG for the construction and preparation of the equestrian arenas at Greenwich for the London 2012 Olympic Games [4].

ii) Increased awareness in the equine sector of the need for industry standards for equestrian arena surfaces

Since the publicity surrounding the equestrian arenas constructed on a raised platform for London 2012, there has been greater interest in arena surfaces from both the equestrian public and the overriding regulatory bodies at national and international levels.

Collaboration with other researchers (identified above) has meant that we have developed key terms to describe functional properties of surfaces, as defined in the White Paper (Hobbs *et al*., 2013), now endorsed by the FEI [1, 2, 3] . The White Paper (Hobbs *et al*., 2013) is the first internationally recognised step in educating the equestrian public about matters related to equestrian surface use and management [1, 2, 3]. We anticipate that the key terms described in the White Paper will be adopted by riders to encourage greater understanding and promote standard terminology for surface characteristics.

The full citation for the White Paper, now approved for publication by the FEI (online publication is likely to be in late 2013), is:

Hobbs, S.J., Northrop, A.J., Mahaffey, C., Martin, J.H., Clayton, H.M., Murray, R., Roepstorff, L., and Peterson, M. 2013. Equine Surfaces White Paper.

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

[1] Professor of Mechanical Engineering, Department of Mechanical Engineering, University of Maine, USA

[2] Senior Veterinarian and Orthopaedic Advisor, The Animal Health Trust, Newmarket, UK

[3] Professor of Equine Functional Anatomy, Institute for Anatomy and Physiology, Swedish University of Agricultural Sciences, Uppsala, Sweden

[4] Technical Director, The Environmental Protection Group Ltd, Warrington, UK

[5] General Manager, Andrews Bowen Ltd, supplier of equestrian riding surfaces (Greenwich Park) to the London 2012 Olympic Games (see http://www.andrewsbowen.co.uk/ )

[6] Research Council UK Bronze Podium Award for exceptional research contribution to the London 2012 Olympic Games (see http://www.podium.ac.uk/showcase/view/209/bronze-medallists-for-research-councils-uk-award-for-exceptional-research-contribution )

Expanding on [6], above, the following quotation is taken from the Podium website page for the bronze awards:

'*RACES - Assessment of footing in the equestrian arenas at Greenwich Park has developed tests to monitor footing for the equestrian arenas for London 2012 to increase knowledge and to reduce injury. Partners include Anglia Ruskin University, Myerscough College and the University of Central Lancashire*. For more info: alison.northrop@anglia.ac.uk / www.anglia.ac.uk'