Institution: University of Cumbria

Unit of Assessment: 26 - Sport and Exercise Sciences, Leisure and Tourism

Title of case study: Improving training through testing context appropriate muscle function assessment techniques to support effective coaching practice and athletic performance.

1. Summary of the impact

The applied research generated has targeted practitioners and athletes at all levels, and by combining expertise and knowledge from different areas (primarily Biomechanics and Physiology), aimed to directly influence the way in which muscle function is assessed in competitive sports. The studies in the area of muscle conditioning and function has generated a body of work that has the potential to be useful to coaches both in competition as well as in training, but to date has not been fully realised. By examining how the muscle responds to certain stimuli, training suggestions have been provided that can acutely increase the performance of an athlete, for example conditioning stimuli prior to athletics performance (reference 4 in section 3). These suggestions can assist both in improving the competitive performance as well as in improving the quality of the content and experience of training sessions.

Further, evaluating a range of tests and assessment tools, such as by examining their validity and reliability, monitoring and assessment becomes much more accurate and sport-specific, enabling high-quality training (such as in reference 2, section 3). In addition, as these assessments allow testing to take place within the training and performance environment the performer is accustomed to (such as in reference 6, section 3), they also result in minimal disruption of the training programme, which cannot be achieved using traditional assessment techniques which require a visit to a laboratory for the assessment to take place.

The range of applicability of the research to support uptake of the recommendations and resultant training and performance benefits has been maximised by ensuring the suggestions and equipment used are low cost and easily accessible, enabling coaches and athletes from a wide range of performance levels to utilise them, such as functional tests (such as in reference 5, section 3). The work has highlighted that coaches and athletes need to reassess their approaches to measuring performance and specific measurement techniques used, and that doing so can improve training techniques and athletic performance.

2. Underpinning research

The research undertaken relates to muscle function and assessment within competitive sport. Existing standard practice primarily focuses on assessment of muscle function in a controlled laboratory environment, with little transfer into sport-specific situations and contexts in which sport practice (including competition) normally occur, such as water polo, team games, running and functional activities. A gap was therefore identified; however before this could be fully explored the assessment methods needed to be evaluated and verified. Once these assessments had been evaluated, further questions arose in that some of the assessments currently used were not specific to the sport or environment and therefore lacked reliability and validity.

Most of the research conducted is applied in nature, as it derives from established and acknowledged gaps, identified through engagement with coaches or through relevant literature. The practical need driving the studies undertaken came from the lead researcher's own practice experience as a UK national water polo coach, and was explored through research in academic posts. The wider need for contextual performance analysis was further identified through discussions with coaching and academic colleagues from different disciplines: confirming widespread issues in assessment and training to the ones faced in water polo. For example, with Paul Jones, a Biomechanist working with UK Athletics, a need was identified for more information on functional imbalance tests when assessing athletes, leading to a study on functional tests (reference 4, section 3). Similarly, with Joseph Esformes, a Strength and Conditioning specialist working with athletes from various sports, we identified an opportunity to enhance athletic training, which led to projects utilising post-activation potentiation (references 3 and 4, section 3).

The studies outlined below, led by Theodoros Bampouras, give an overview of the body of work and the collaborations with a number of key colleagues, both internally and externally:

University of Cumbria:

- Theodoros Bampouras, Senior Lecturer in Sport Mechanics and Performance Analysis, 2007 onwards.
- Nicola Relph, Teaching Research Assistant 2006 to 2010, Lecturer in Biomechanics 2010 onwards.

External colleagues in other HEIs:

- Dr Joseph Esformes, Senior Lecturer in Sport and Exercise Physiology, Cardiff Metropolitan University.
- Dr Kelly Marrin, Senior Lecturer in Sport and Exercise Physiology, Edge Hill University.
- Dr Paul Jones, Lecturer in Sport Biomechanics and Strength and Conditioning, University of Salford.

Key research projects:

- Comparison of two water-polo, pool-based anaerobic tests to a laboratory-based anaerobic power measurement to examine associations and feasibility of comparisons of field-based assessment to laboratory-based assessment (TB, KM, 2008-2010).
- Examined different activities (bodyweight plyometric activities versus heavy weights) and their effect on subsequent power performance, to examine whether plyometrics can serve as a method of acute power enhancement negating the need for equipment (JE, TB, 2009-2010).
- Comparison of field-based, functional muscle imbalance tests to a laboratory-based muscle imbalance test to examine associations and feasibility of comparisons of field-based to laboratory-based assessment and their utility (TB, KM, 2008-2010).
- Examined different upper body muscle contractions (concentric, eccentric, dynamic, isometric) and their effect on subsequent power performance, to provide a method of acute power enhancement without the need for equipment (JE, TB, 2009-2010).

The research has given new insights into how:

- Muscle performance can be acutely improved or maintained following initial contractions. These findings demonstrate how the phenomenon of post-activation potentiation can be utilised in performance such as in athletics, furthering previous laboratory-based research.
- Assessment methodology in terms of procedures, equipment and technique used is key to the outcome measurement gained. Further, sport specificity, precision and accuracy must be carefully evaluated as they guide monitoring and programme design. Tests currently used need to be re-visited to establish their appropriateness.
- Performance assessment can be effectively performed in the field as opposed to the more time consuming and costly laboratory environments.

3. References to the research

1. Esformes, J.I., **Bampouras, T.M.** (2013) Effect of back squat depth on lower body post-activation potentiation. *Journal of Strength and Conditioning Research* 27 (11): 2997-3000 doi: 10.1519/JSC.0b013e31828d4465.
2. **Bampouras, T.M., Relph, N.,** Orme, D., Esformes, J.I. (2013). Validity and reliability of the Myotest Pro wireless accelerometer. *Isokinetics and Exercise Science*. 21, 101-105.
3. Esformes, J.I., Keenan, M., Moody, J., **Bampouras, T.M.** (2011). Effect of different types of conditioning contraction on upper body postactivation potentiation. *Journal of Strength and Conditioning Research*, **25**, 143-148.
4. Esformes, J.I., Cameron, N., **Bampouras, T.M.** (2010). Post-activation potentiation following different modes of exercise. *Journal of Strength and Conditioning Research*, **24**, 1911-1916.
5. Jones, P., **Bampouras, T.M.** (2010). A comparison of isokinetic and functional methods of assessing bilateral strength imbalance. *Journal of Strength and Conditioning Research,* **24**, 1553-1558.
6. **Bampouras, T.M.**, Marrin, K. (2009). Comparison of two water polo specific tests to the Wingate anaerobic power test. *Journal of Strength and Conditioning Research*, **23**, 336-340.

The quality of the research is verified by the rigorous peer-review process all papers have undergone before publication. Additionally, it can be seen in the increasing number of citations of the work, as well as the interest it generates to coaches (i.e. the intended audience; see Section 4) implementing training programmes. The studies have served as impetus for further work by practitioners, directly (e.g the Tunisian Research Laboratory "Sports Performance Optimisation" National Center of Medicine and Science in Sports (CNMSS), Tunis, Tunisia; and the Sport Science Department, ASPIRE, Academy for Sports Excellence, Doha, Qatar). Both of these athlete training facilities have utilised the Esformes et al (2010) and Jones et al (2009) papers, as well as indirectly (e.g. Narducci et al the Department of Physical Therapy, Walsh University, Ohio using the Jones and Bampouras (2010) paper as a quality paper in their systematic review).

4. Details of the impact

As outlined in section 2, the research is intrinsically designed to generate impact for coaches and athletes, which is also reflected in the route for dissemination of the academic articles through practitioner-focussed journals. The uptake of the research by end users is predominantly shown through these channels. The most recent article (Esformes and Bampouras, November 2013), accepted for publication by the *Journal of Strength and Conditioning Research* on 25th February and available to view online ahead of print, features in the Journal's most e-mailed articles (i.e. peer practitioner sharing through social media), and has already been cited a number of times on fitness interest websites (such as T Nation and CrossFit-APx). The Esformes et al (2010) article is one of the journal's most popular, according to their Twitter feed (which has over 10,000 followers, the majority of whom will be athletes or coaches). The *Journal of Strength and Conditioning Research* is a key route to reaching practitioners, as it specifically targets practitioners as "a unique aspect [of this journal] is that it includes recommendations for the practical use of research findings". The Journal is affiliated to the National Strength and Conditioning Association (30,000 members in 72 countries), whose aim is to ''bridge the gap'' from the scientific laboratory to the field practitioner. In addition, the Esformes et al (2010) paper is one of the 'Most recommended' papers in BioInfoBank Library, an open access, free online resource promoting science.

Secondly, the research features on various athletic websites providing advice to athletes. For example, the Australian Fitness Network (10,000 fitness instructors as members) utilised the Jones and Bampouras (2010) paper to make assessment suggestions on leg strength assessment based on the finding of this study. Similarly, the Center for Optimal Recovery, a website designed for athletes and offering advice on training and avoiding injury, has used the recent Esformes and Bampouras (2013) study to make training suggestions. The research is also picked up in a number of other blogs and websites around coaching and reflection on practice, indicating that it stimulates debate around designing training programmes and assessment of performance.

The articles on post-activation potentiation have created interest from academics (e.g. Esformes et al, 2010 cited 15 times; Esformes et al, 2011 cited 4 times) as well as practitioners, due to the simple and applied suggestions they make. As post-activation potentiation is a relatively new area of research, much of the literature revolved around laboratory-based conditions, with little transfer to the field. However, the articles on post-activation potentiation have clear application to the athletes by making suggestions on how to improve power performance acutely with simple, low-resource exercises. An early indicator of the applicability of this work in shaping training is through citation of research findings by a company who design training aids, specifically Freq Reflex™, a product which the company are working directly with trainers.

In addition, Bampouras is an invited contributor to practitioner education through delivery of sessions on Muscle and Tendon Conditioning on the MSc Strength and Conditioning degree at the University of Bolton, since the course began in 2008, the context of which is based on the research insights. Further, Bampouras and other colleagues were invited by Active Cumbria, an organisation dedicated to delivering Sport and Physical Activity in Cumbria, to deliver workshops to coaches working with athletes from different sports and of various performance levels. These workshops for part of the organisation's Coaching Plus Development programme and the workshops Bampouras delivered were on *Periodisation* and *Introduction to Strength and Conditioning*. Evaluation from coaches attending revealed that the most useful information was "*Practical ideas you can incorporate into training really easily with minimum cost involved*"; "*Training info"*; "*How simple it*

can be"; "*Assessment bits*"; and "*Conditioning exercises*", suggesting that the information provided was perceived as useful and easy to implement in their practice.

Bampouras' work on muscle conditioning and assessment has informed scientific support services provided to various athletes, with the prime example being support provided to an athletics sprinter (U23 England Championships finalist). Assessment of muscle function and subsequent advice on training and improving performance was based on the research on muscle imbalance assessment, power improvement and periodization.

Staff within the unit have also undertaken work with the Team GB diving squad to assess and improve performance. This work was undertaken by Nicola Relph and a former colleague from the unit, and provided mechanical analysis of some of the most difficult dives, used to inform the focus of training programmes. This resulted in improved performance for synchronised divers in 2012 in relation to 2008 results. Relph and Bampouras have co-authored papers on testing techniques (such as reference 2 in section 3), and the research followed the principles of the body of work in relevant *in situ* testing for performance assessment.

Finally, research that has been undertaken on water polo training (e.g. Bampouras and Marrin, 2009) has resulted in altering training and assessment practices of the National Scottish Women's water polo team, in light of the findings and suggestions of the body of work around the sport. For example, the previously used 30 seconds cross bar jumps as a measurement of lower leg power in water polo players, was abandoned due to findings by Bampouras and Marrin (2010). Training loads and monitoring was compared and designed around Marrin and Bampouras (2009) and Marrin and Bampouras (2008), which informed the training process, assisted in player selection as well as educated the players. The engagement with the team, including both individual and team performance analysis, has contributed to the promotion of the team to the top division.

5. Sources to corroborate the impact

- http://www.speedfreq.co.uk/science.php A sports training equipment company that has utilised Esformes et al (2010) to design Freq Reflex™; the company's owners directly train athletes themselves.
- http://twitter.com/NSCA/status/22121831670 - Esformes et al (2010) stated as journal's most popular on 25th August 2010, and continues to be in this list. (*National Strength and Conditioning Society* – NSCA twitter feed). 10,318 followers.
- http://www.fitnessnetwork.com.au/resources-library/a-practical-approach-to-leg-strength - Australian Fitness Network for Fitness Instructors, training suggestions for leg strength using Jones and Bampouras (2010).
- http://centerofoptimalrestoration.com/2013/03/06/crossfit-hydration-fatigue-lung-volumes-dynamic-stretching-post-activation-potentiation-core-stability/ - Centre for Optimal Recovery, a free training advice website for athletes, training suggestions for increased jumping performance using Esformes and Bampouras (2013).

The following has provided a statement, available on request:

- Sports Science / Sports Medicine coordinator, British Diving, to corroborate impact on Team GB diving coaching, training programmes and performance.

The following organisations and individuals can corroborate the adoption of the research into practice:

- Scotland Water Polo Development Officer, Scottish Swimming, to corroborate impact on training programmes and performance with the National Scottish women's team.
- Athlete working with Bampouras, to corroborate impact on training programmes and performance through work with an athlete and coaches.
- Development Officer-Coaching, Cumbria County Council, to corroborate impact on coach education and development with Active Cumbria.