Institution: Loughborough University

Unit of Assessment: C26 Sport and Exercise Sciences, Leisure and Tourism

Title of case study: Improved coaching and performance arising from research on the biomechanics of twisting somersaults

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

Research at Loughborough University on twisting somersaults has had impact in the current (2008-2013) coaching and performance of trampolining, gymnastics, diving and the aerials event in freestyle skiing. The findings have been adopted as the basis of coaching twisting somersaults by coaches in these sports from many countries including the UK, Netherlands, Canada, USA, Australia and China. The improvements in coaching and performance have changed these sports globally, have benefitted individual athletes in terms of being able to train more safely and compete more successfully, and have benefitted spectators in terms of an enhanced spectacle in competitive events.

2. Underpinning research (indicative maximum 500 words)

This research was carried out by Dr M.R. Yeadon (1990-present) at Loughborough University between 1993 when he was Senior Lecturer and 2013 when he was Professor of Computer Simulation in Sport. This comprehensive and unique research into twisting somersaults was based upon three-dimensional image analysis of performances together with theoretical computer simulations, giving key insights into the mechanics of aerial movement and implications for coaching.

The mechanics of twisting somersaults is considered from a theoretical perspective in a four part research article **[3.1]**. The mechanics of rigid body aerial motion shows that there are two modes of motion: the twisting somersault and the wobbling somersault. This provides a basis for understanding more complex motions of a multi-segmented system which can move from one mode of motion to another. The abilities of contact and aerial techniques to initiate and control twist are established using computer simulations of an 11-segment link model of the human body. A method is presented for partitioning twisting techniques used in recorded performances into a contact component and aerial components corresponding to symmetrical movements, asymmetrical arm movements and asymmetrical hip movements. The key findings are that (a) twist may be initiated during the flight phase aerial using asymmetrical arm and hip movements to produce tilt of the longitudinal axis away from the vertical somersault plane, (b) tilt may also be removed using asymmetrical movements resulting in the cessation of twist, (c) aerial techniques make a greater contribution than contact techniques to twisting in elite trampolining performances **[3.1]**.

Subsequent articles **[3.2, 3.3, 3.4, 3.5]** apply the method of partitioning twisting techniques to competitive performances in springboard diving, rings dismounts, high bar dismounts, and twisting somersaults on floor. Again it was found that aerial techniques make a greater contribution than contact techniques. The limits of aerial twisting techniques in the aerials event of freestyle skiing are established in **[3.6]** by optimising simulated performance for 10 aerial twisting techniques using specific asymmetrical movements of arms and hips. The article provides detailed analyses of the 10 techniques. The key finding is that (d) a maximum of six twists will be possible in a triple somersault.

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

Publications

3.1. Yeadon, M.R. 1993. The biomechanics of twisting somersaults. Parts I-IV. Journal of Sports Sciences 11, 187- 225. DOI: 10.1080/02640419308729985 - 10.1080/02640419308729988

3.2. Yeadon, M.R. 1993b. Twisting techniques used by competitive divers. Journal of Sports Sciences 11, 4, 337-342. DOI: 10.1080/02640419308730003

3.3. Yeadon, M.R. 1994. Twisting techniques used in dismounts from rings. Journal of Applied Biomechanics 10, 2, 178-188. http://hdl.handle.net/2134/8674

3.4. Yeadon, M.R. 1997. Twisting double somersault high bar dismounts. Journal of Applied Biomechanics 13, 76-87. http://hdl.handle.net/2134/8787

3.5. Yeadon, M.R. and Kerwin, D.G. 1999. Contributions of twisting techniques used in backward somersaults with one twist. Journal of Applied Biomechanics 15, 152-165. http://hdl.handle.net/2134/6237

3.6. Yeadon, M.R. 2013. The limits of aerial twisting techniques in the aerials event of freestyle skiing. Journal of Biomechanics 46, 1008-1013. DOI: 10.1016/j.jbiomech.2012.11.029

Evidence of quality of the research

The research was published in a range of good international peer reviewed scientific journals. Research in this area comprised a major part of Dr Yeadon's application for a personal chair which was vetted internationally and awarded in 2000. Additionally this research was a major factor in Dr Yeadon being awarded the Geoffrey Dyson Award in 2008 by the International Society of Biomechanics in Sports and Honorary Membership of the International Society of Biomechanics in 2011.

Underpinning Research Grants

G3.1. British Gymnastics, 1993-1998: £133,000 (Biomechanics Analysis)

G3.2. British Gymnastics, 1998-2007: £515,000 (World Class Performance)

G3.3. Science Research Investment Fund, 2001-2003: £1,160,000 (Gymnastics Research Centre)

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

The theoretical mechanics base for the understanding of aerial movement provides a framework for designing coaching progressions to learn twisting somersaults. Without this understanding of the mechanics coaches have generated their own ideas on the basis of practical experience. Such ideas have wide variation, conflict with each other, and often have little practical or theoretical basis. With an understanding of the mechanics, coaches have common ground and are better able to communicate with each other to make sense of their practical experience of aerial movements. Many of the top coaches are former competitors who were able to perform the skills without understanding the mechanics. Now with a mechanics base they are able to coach to a high level, giving detailed technical instruction to their athletes. As a consequence there has been an impact on (a) improved coaching leading to (b) improved performance by athletes in the period January 2008 to July 2013.

In gymnastics and trampolining the tilt-twist concept has become universal for advanced aerial skills and the International Gymnastics Federation teach it in Gymnastics, Trampolining and Acrobatic Gymnastics Academy Courses, referencing Dr Yeadon as the world expert in this area **[5.1]**. Most apparatus dismounts and the double somersaults with twist on floor in Artistic Gymnastics are now learned consciously with tilt-twist techniques whereas in the past this was more accidental than deliberate **[5.1]**. In 2009 Dr Yeadon received the Special Recognition Award from the Nik Stuart Foundation for his contribution to gymnastics from his research work.

In Canada gymnastics and trampoline coaches use the research of Dr Yeadon as a basis for teaching twisting somersaults since it has been incorporated into the coach education programmes **[5.2]**. This knowledge is currently being incorporated **[5.2]** into the gymnastics coach education materials of a number of countries (Norway, Sweden, Portugal, Japan).

USA Diving developed coaching progressions based on the results of this research that have led to international first performances of twisting dives **[5.3]**.

In the aerials event of freestyle skiing in which triple somersaults are performed with twist the research results of Dr Yeadon currently form the basis of coaching specific asymmetrical arm movements for producing and removing tilt in the USA and Canada **[5.4, 5.5]**. Additionally tilt twist is coached in Australia, China, Russia, Japan and Switzerland **[5.5]**.

In summary there has been a significant impact with a Sea-change in coaching and acrobatic performance and with a large current reach across many countries (USA **[5.3, 5.4]**, Canada **[5.2, 5.5]**, China **[5.5]**, Russia **[5.5]**, Japan **[5.2, C5]**, Australia **[5.5]**, Norway **[5.2]**, Sweden **[5.2]**, Switzerland **[5.5]**, Portugal **[5.2]**) and many sports (gymnastics **[5.1, 5.2]**, trampolining **[5.2]**, diving **[5.3]**, freestyle skiing **[5.4, 5.5]**). In addition to the improvements in coaching and performance individual athletes have benefitted in terms of being able to train safely and compete successfully and spectators have benefitted in terms of an enhanced spectacle in competitive events **[5.1]**.

Routes to Impact

The impact described above has been effected in a number of ways. Dissemination of information arising from the under-pinning research has comprised: (a) sport conference presentations (e.g. Yeadon, 1999); (b) presentations to national governing bodies of sport (c) a chapter for a book commissioned by United States Diving (Yeadon, 2001); (d) general interest publications such as Yeadon (2000); (e) lectures to 5000 university sport students; (f) the website of the Sports Biomechanics and Motor Control Research Group; (g) the Loughborough University Library publication repository. Institutional support for dissemination has comprised travel funds for international conference presentations and presentations to sporting bodies.

Examples of Dissemination publications for coaches

(1) Yeadon, M.R. 1999. Learning how to twist fast. Coaching Symposium on Acrobatics. Proceedings XVII International Symposium of Biomechanics in Sports. ISBS. Perth, 30 June - 6 July.

http://www.lboro.ac.uk/microsites/ssehs/biomechanics/papers/twistfast99.pdf

(2) Yeadon, M.R. 2001. Twisting. In Biomechanics of Competitive Diving, (Ed. D.I. Miller), pp. 217-236. Indianapolis: United States Diving.

http://hdl.handle.net/2134/5474

(3) Yeadon, M.R. 2000. The physics of twisting somersaults. Physics World, Sep, 33-37.

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

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

5.1. Letter from Director, International Gymnastics Federation (FIG) Education and Academy Programmes

5.2. Letter from President, International Gymnastics Federation (FIG) Scientific Commission

5.3. Letter from Director, USA Diving

5.4. Letter from Head Aerial Coach, United States Ski Team

5.5. Letter from National Coach, Canada Freestyle Skiing