

Institution: University of Wolverhampton		
Unit of Assessment: 24 Sport and Exercise Sciences, Leisure and Tourism		
Title of case study: Keeping Dancers Dancing: Reducing Injury Incidence and Improving Performance Capabilities		
Period when the underpinning research was undertaken: 2014-2020		
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:
Professor Matthew Wyon	Professor in Dance Science	2002-present
Professor Yiannis Koutedakis	Professor in Applied Exercise Physiology	1991-present
Professor Alan Nevill	Professor in Biostatistics	1999-present
Professor George Metsios	Professor in Clinical Exercise Physiology	2007-present
Period when the claimed impact occurred: 2014-2020		
Is this case study continued from a case study submitted in 2014? N		
1. Summary of the impact <p>Our research has focused on aspects of health in general and bone mineral density (BMD) in particular relating to vocational and professional dancers. It has the objective of reducing injury incidence and improving the dancers' wellbeing. Overall, the impact of this work has resulted in the following four main changes:</p> <p>11a) The training regimes of dancers have changed in order to limit injury and reduce subsequent dropout rates. In one instance, this led to a 27% reduction in dropout;</p> <p>11b) We have developed a neuromuscular warm up (Dance 11+) which, along with the introduction of strength and conditioning (S&C) training within the dance curriculum, has led to a 40% decrease in injuries at one ballet school alone;</p> <p>11c) Our research discovery that 87% of students had insufficient/deficient serum 25(OH)D has led to year-long monitoring of vitamin D levels of vocational and professional dancers, with accompanying vitamin D supplementation; and</p> <p>12) We have worked with dance schools and companies to show how imperfections in dance floors can lead to injuries and why this is a risk to dancers; further impacts were tested in court with Wyon as an expert witness.</p> <p>Together, the results of our research and the impact achieved have benefitted dancers' health and wellbeing. This work has informed national guidelines of the National Institute of Dance Medicine and Science, UK, and the National Centre for Performing Arts, Netherlands, as well as international guidelines of the International Association for Dance Medicine and Science (IADMS).</p>		

2. Underpinning research

The focus of the team has been to apply and implement the principles of exercise science to dance. The research produced novel findings on the stresses placed on 11-18 and 18-22 year old dancers in vocational training [Findings F1-5] and professional employment [F1-6].

Research has focused on two main areas: the improvement of dancers' health [F1-3] and muscular function (both strength and power) [F4 and F5]. In partnership with industry (Harlequin Floors, Safe in Dance International) and end-user collaborations (Elmhurst Ballet School, Birmingham Royal Ballet, ArtEZ Conservatoire), we have applied targeted and comprehensive interventions to reduce injury incidence and improve performance capabilities.

Findings are grouped below as follows: F1-F4 cover aspects of bone mineral density (BMD), F5 covers fitness, and F6 relates to dance floors.

F1-4. Dancers' disordered eating, bone mineral density, vitamin deficiency and muscle function

F1. The fact that there is a need for ecto/mesomorphic somatotypes, especially in ballet, starting from ~11 years old, places great stress on the young dancers to conform to body leanness, resulting in a higher incidence of disordered eating than in the general population [R1].

F2. The ecto/mesomorphic characteristics found in dancers are also associated with lower than normal BMD in female dancers as young as 13 years of age, which could eventually lead to osteoporosis [R2].

F3. We discovered that factors traditionally associated with low bone mass phenotypes in elite dancers do not fully explain the low bone mass values. Instead, we have provided evidence that genetic variants at the Wnt/ β -catenin and ER signalling pathways may be potential risk factors for the observed low BMD, which are also linked to the industry's preferred ectomorphic body type [R2]. However, areas of loading, such as the femur, had higher BMD than controls highlighting the benefits of dancing even when other factors indicate an increased risk [R3].

F4. Indoor training exasperates the previously mentioned effects by causing vitamin D deficiency, which negatively affects BMD, muscular strength and injury incidence. We have shown that supplementation of vitamin D improves muscle function and reduces incidence of injury [R4]. Our vitamin D research has led to a cultural change in the dance community worldwide and companies and schools now promote vitamin D monitoring to alleviate the deficiency epidemic within the community.

F5. Physical fitness of dancers

As physical conditioning level is a significant factor in dance injury [R4], our performance research has focused on cardiorespiratory profiles, demands and adaptations in a range of dance genres. Our studies have provided new key insights into cardiorespiratory adaptations during vocational contemporary dance training, and performance demands of two street dance styles and musical theatre. These relate especially to 'rehearsal periods leading up to a performance period or tour, relative to the specific demands of the performance repertoire' and the question of economy of movement [R5].

F6. Dance floors

Working with the world's leading dance floor manufacturer and supplier to the Royal Ballet (Harlequin Floors), we have highlighted issues with previous industry guidance on dance floors. Specifically, we demonstrated that variability within the surface is what leads to a higher injury incidence, rather than the surface's overall force reduction rating [R6].

3. References to the research

The following research has been through a rigorous peer-review process and has been awarded peer-reviewed funding. For example, R2 and R4 have been cited not just by researchers in the same field of enquiry but others too, such as in genetics, demonstrating that they are points of reference for further research beyond the original institution. Wyon received the One Dance UK Award for Dance Science (2018), and the One Dance UK Award for Research Impact (2018) in recognition of the significance of his research.

R1. Wyon M, Hutchings K, Wells A, and Nevill A (2014). Body mass index, nutritional knowledge, and eating behaviors in elite student and professional ballet dancers, *Clinical Journal of Sport Medicine*, 24(5): 390-396. DOI: 10.1097/JSM.0000000000000054

R2. Amorim T, Durães C, Machado JC, Metsios GS, Wyon M, Maia J, Flouris AD, Marques F, Nogueira L, Adubeiro N, and Koutedakis Y (2018). Genetic variation in Wnt/ β -catenin and ER signalling pathways in female and male elite dancers and its associations with low bone mineral density: a cross-section and longitudinal study, *Osteoporosis International*, 29(10): 2261-2274. DOI: 10.1007/s00198-018-4610-x (REF 2 Output)

R3. Amorim T, Koutedakis Y, Nevill A, Wyon M, Maia J, Machado JC, Marques F, Metsios GS, Flouris AD, Adubeiro N, Nogueira L, and Dimitriou L (2017). Bone mineral density in vocational and professional ballet dancers, *Osteoporosis International*, 28: 2903–2912, DOI: 10.1007/s00198-017-4130-0

R4. Wyon M, Wolman R, Kolokythas N, Sheriff K, Galloway S, and Mattiussi, A (2018). Effect of vitamin D on muscle function and injury in elite adolescent dancers: A randomized double-blind study, *International Journal of Sports Physiology & Performance*, 14(1): 55-59, DOI: 10.1123/ijsp.2018-0084 (REF 2 Output)

R5. Beck S, Wyon M, and Redding E (2018). Changes in energy demand of dance activity and cardiorespiratory fitness during one year of vocational contemporary dance training, *Journal of Strength and Conditioning Research*, 32(3): 841-848 DOI:10.1519/JSC.0000000000002357

Grant

Grant R20993-1, Elmhurst Ballet School, UK £54,000 – Strength training in adolescent dancers.

4. Details of the impact

To ensure impact as well as long-term applicability and sustainability we have and continue to work in collaboration with key stakeholders and end-users and developed strong pathways to impact. Our research has been disseminated in resource papers for the dance community through One Dance UK, the International Association for Dance Medicine and Science and the 4dancers.org community. Through our research collaboration with Birmingham Royal Ballet, we were commissioned by the BBC to demonstrate how dance science supports elite performance [C1]. Further afield, collaborative links with colleagues in Brazil and Greece have spawned continuing collaboration in the areas of vitamin D and Parkinson's disease. As a result, Wyon was recognised at One Dance UK's inaugural Dance Awards (2018), firstly for Dance Science and secondly for Research Impact [C2], while Koutedakis was the invited closing ceremony Keynote Speaker at the 2018 IADMS World Congress, Helsinki, Finland.

We have been strategically working with several organisations (One Dance UK, IADMS, Safe in Dance International) which are world leaders in dance health promotion [C2, C3]. The dividends are felt by dancers worldwide, through product testing (dance floors) and informing dance schools, company health teams, and dance teacher training courses. Emerging impact has also been evident through capacity building. We have a strongly integrated research philosophy that has led to our MSc and PhD students being involved with our projects, publishing in peer-reviewed

journals and presenting at international conferences. They have applied their new knowledge into their workplaces to change dance practice (e.g. Birmingham Royal Ballet [C4]; Hong Kong Academy of Performing Arts [C5]) further underpinning our team's national and international leadership and impact.

The impact we have engendered has taken place across two areas, which are discussed below.

Impact 1 - Improvement of Health and Wellbeing: Training, BMD, Nutrition

Our research into vocational training has been three-fold: firstly, the training practices of the dancers; secondly, strength and conditioning (S&C); and lastly, vitamin D supplementation [F1-F5].

In the first instance, our research underpinned the development and implementation of the World's first innovative periodised model within pre-professional dance training at ArtEZ Conservatoire, Netherlands. This led to a 27% reduction in student drop out, with an increase in employability at top dance companies and an award by the Dutch government in recognition of its innovative practice [C6]. Subsequently, other dance schools across the world (Portugal, Brazil, Hong Kong, USA, UK) have started to change the way their dancers are trained [C7].

Secondly, acknowledgment of the impact of our research [F2-F4] led to the first ever industry-sponsored PhD to implement strength and conditioning into a vocational dance school (Elmhurst Ballet School) [C8]. This resulted in the development of a neuromuscular warm up (Dance 11+) which, along with the introduction of S&C training within the curriculum, led to a 40% decrease in injuries at the school. S&C interventions used data from our BMD research to provide future-life protection in dancers. The PhD student was awarded IADMS's Dance Educator of the Year (2019) [C7, C3].

Thirdly, our research [F4] indicated that 87% of students ($n = 67$) tested from an anonymised school [R4] had insufficient/deficient serum 25(OH)D. This has led to year-long monitoring of vitamin D levels of vocational and professional dancers and vitamin D supplementation, as appropriate.

In June 2020, Wyon was asked to be part of national taskforce providing guidance on "Return to Dance" post-COVID lockdown. This involved providing advice to members of the Department of Culture, Media and Sport Taskforce and interpreting the guidance for the dance industry through a series of webinars run by One Dance UK (3,200 attendees) [C9].

Impact 2 - Impact on Dancers and their Fitness involving Dance Floors

The change emerging from engagement with our findings on dance floors has been to reduce the level of injury risk for dancers [F3, F4]. We showed that within floor deformation variability (how the floor is constructed) is an increased injury risk which is of special concern for touring dance companies [F6]. These findings have had an effect on a variety of stakeholders. Touring Dance companies purchased transportable dance floors for their tours [C4] (e.g. Birmingham Royal Ballet, English National Ballet, Adventures in Motion). Wyon was employed as an expert witness by lawyers for Disney in a recent successful court case providing 'vital' evidence on the influence of a dance floor on an "end of career" injury claim [C10]. The legal dimensions have resonance overseas [C10].

5. Sources to corroborate the impact

C1. BBC clip on physiological and biomechanical demands of elite dance performance (7.2k views) <https://www.facebook.com/watch/?v=347838329252493>

C2. Letter from CEO, One Dance UK

- C3. Letter from the President of International Association for Dance Medicine and Science
- C4. Letter from the Clinical Director, Birmingham Royal Ballet
- C5. Letter from Hong Kong Academy for Performing Arts
- C6. Letter Director of Dance and Theatre, ArtEZ Hogeschool voor de Kunsten, Netherlands
- C7. Letter from the International Association for Dance Medicine and Science's (IADMS') Dance Educator's Committee
- C8. Letter from the Elmhurst Ballet School
- C9. Return to Dance Webinars <https://www.onedanceuk.org/return-to-dance/#STAY-UP-TO-DATE>
- C10. Letter regarding court case from Kennedy's Solicitors representing Disney