Injury

SS-0078

SIMULATION AND PROPHYLACTIC RESEARCH: INTERESTING BEDFELLOWS

Cyril J. Donnelly [1,*] Jeff Reinbolt [2] Gillian Weir [1] Kristin Morgan [3] Jacqueline Alderson [1]

[1]School of Sport Science, Exercise and Health, The University of Western Australia, Perth, Australia, [2]Department of Mechanical, Aerospace and Biomedical Engineering, University of Tennessee, Knoxville , [3]Division of Physical Therapy, University of Kentucky, Lexington, United States

Introduction and Objectives: Modern biomechanics can be dated back to the late 1800's, with the invention of stop-action photography by Eadweard Muybridge [1], which was developed to describe animal motion that could not be observed with the human eye. Later, with the development of the force platform [2], and the application of the Newton-Euler equations of motion, the ability to calculate the forces that cause human motion became possible. With the invention of the programmable computer in the 1950's and the evolution of the silicon processor, our ability to create dynamic simulations has become an apparent reality. Now, over 100 years later, following significant scientific and technological advancements, simulation based research has firmly established its place within the field of biomechanics. The purpose of this manuscript will be to present an applied example of how simulation based research has been used to inform the development of an effective knee injury prevention training protocol.

With the use of the open-source musculoskeletal modelling framework OpenSim, our group has been using simulation based experiments to better understand how specific movements and/or muscle forces during a movement are related to an athlete's lower limb injury risk in sport. Using the residual reduction algorithm, we were able to optimize an athlete's technique to reduce their risk of knee injury during unplanned sidestepping tasks. Through simulation, we showed a causal relationship exists between an athlete's upper body mechanics, knee loading and injury risk during dynamic sporting tasks [3]. We then used computed muscle control to measure and characterize the muscle forces an athlete uses during single-leg landing tasks. Findings from this research showed that the gastrocnemius muscles are used significantly more than the hamstring muscles to stiffen and support the knee during the impact phase of single-leg landing [4]. From these simulation findings and relevant prophylactic research, we have developed and implemented a novel prophylactic training intervention designed to reduce and athlete's risk of knee injury in sport.

Methods: The Australian national field hockey team participated in a novel nine-week body-weight based training intervention. The intended focus of the intervention was to A) improve gluteal muscle strength, increasing an athlete's capacity from attaining 'dynamic-valgus' knee postures, which have been shown to predict anterior cruciate ligament (ACL) injuries in sport [5]. From our group's simulation findings, added foci were to B) improve the dynamic control of the upper body and C) improve the strength of the gastrocnemius muscles. During training, athletes' performed a range of strength, plyometric and balance exercise that continually targeted on or all of the intervention's intended foci. Prior to and following the training intervention, full-body kinematics, lower body kinetics and lower limb muscle activation were collected for 16 athletes during the UWA sidestepping protocol. All experimental methods have been described previously [6, 7].

Results: Following training, athlete's identified as 'high-risk' from their knee moments during unplanned sidestepping (n = 5) significantly reduced their peak valgus knee moments by 28% (p = 0.024), becoming consistent with valgus knee moments observed pre- post training from the 'low-risk' group (n = 11). All athletes (n = 16) were better able to utilize their hip versus their knee to generate their support moment during sidestepping, redistributing the relative contribution of their support moment from their knee to hip (Cohen's d = 0.56). For all athletes (n = 13), total gluteal muscle activation significantly increased by 27% (p = 0.006), while co-contraction of the hamstring muscle group were re-directed from the biceps femoris to the semimebranosus (Δ226%, p < 0.001). It is likely an athlete's capacity to prevent hip internal rotation, which is associated with the 'dynamic-valgus' posture would be improved. Increases in medial hamstring muscle activation would help athlete's support their knee against valgus knee moments, which is a surrogate for ACL injury risk [3, 5, 6]. We are currently analysing further motion capture data from this population to determine if these positive training effects have been preserved following 16-weeks of maintenance training.

Figure:

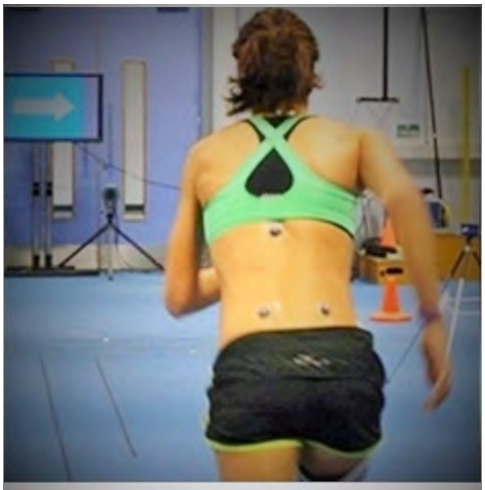

Figure 1: Depiction of UWA sidestepping protocol.

Conclusion: Simulation research can be used to help inform the development of effective lower limb injury prevention training protocols. The efficacy of a novel hip, trunk and gastrocnemius focused training intervention has been verified among elite level female field hockey players.

References: [1]Muybridge, *Scientific America,* 1878.
[2]Elfman, *Science*, 88(2276):152-153, 1938
[3]Donnelly et al., *J Biomech.* 45(8):1491-97, 2012
[4]Morgan et al., *J Biomech.* 47(13):3295-302, 2014
[5]Hewett et al., *Am J Sports Med.* 33(4):492-501, 2005
[6]Donnelly et al., *Br J Sports Med.* 46(13):917-22, 2012
[7]Donnelly et al., *Journal of Sci. and Med. in Sport, (In-Press)*

Disclosure of Interest: None Declared