COMPARISON OF INDOOR DROP LANDING EXPERIMENTAL DATA AND 2D FORWARD DYNAMICS MUSCULOSKELETAL MODEL SIMULATIONS FOR EARLY VALIDATION

Petrone N.[1], Marcolin G.[2], Villaminar R.[2], Heinrich D.[3], Nachbauer W.[3]

[1]Departement of Mechanical Engineering, University of Padova, Italy
[2] CEMES, Laboratory for Physical Therapy and Rehabilitation, Padova, Italy.
[3] Department of Sport Science, University of Innsbruck, Austria.

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INTRODUCTION: The development of validated musculoskeletal models is very helpful in the interpretation of skiing dynamics and prevention of ski injuries. Implementation of knee passive structures behaviour in the models is a powerful tool for predicting fall risk factors. A new 2D model of a skier has been developed and is able to simulate safe landing from a jump. Changes in equipments or skiing techniques can be simulated to explore the safe envelope of the landing movement with respect to ACL overloading and to predict possible risk factors for ACL injuries. Aim of the present work was the comparison of experimental data and simulation results after drop tests on force platforms with or without ski-boots.

METHOD: Experimental data were collected on a healthy racing skier of known anthropometry: the tester was asked to perform repeated safe jumps from an increasing drop height landing with the feet on two independent force platforms. The full body kinematics (250 Hz), the ground reaction forces (1kHz) and 8 EMG channels (10 kHz) were captured by a BTS Smart D® system. Drop landings on platforms were performed either barefoot or wearing skiboots of known stiffness properties (Petrone, 2011), after application to platforms of a sheet of foam suitable for simulating the snow dynamic compression behaviour (Federolf, 2001). Foam properties were evaluated by a test machine at different strain rates. Joint kinematics, COM trajectories and integrated EMG were obtained synchronous to the force platform signals. On the other hand, a 2D musculoskeletal model of the skier with 9 degrees of freedom (DOF) was developed. The model, reproducing skier's anthropometry, consists of 7 segments, three segments for each leg and one segment representing the head, arms and torso. Hip, knee and ankle are modeled as 1 DOF hinge joints. The motion of the 2D skier model is actuated by 16 muscles. Activation dynamics is given as a first order process and each muscle follows a three-element Hill model. Interaction between the lower legs and the ground is modeled using a series of spring-damper elements placed under each foot/boot. Direct collocation method (Ackermann and van den Bogert, 2010) is applied to obtain the numerical stimulation patterns of the muscles, the net joint loading at hip, knee and ankle and the ground reaction forces during the drop landing trials. ACL loading is predicted based on the calculated net knee loading and the muscle forces and data of ACL and PCL orientation taken from Herzog and Read (1993). For validation, numerical excitation patterns and experimental EMG as well as measured and calculated ground reaction forces are compared.

RESULTS: Full results will be presented at the conference.

DISCUSSION: The comparison of experimental EMG and numerical stimulation patterns was considered as a first tool for the proper setting of the model parameters, in order to achieve the best simulation results: the insight view of ACL loading was then considered closer to real ligament loads. The result of this work can give higher significance to the simulation results of safe-unsafe landings evaluations when virtually varying the different factors.

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