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Editorial Preface

This book contains the abstracts to the WBV 2017 – the 6th International Conference on Whole-Body Vibration Injuries, in Gothenburg, Sweden, June 19-21, 2017. The excellent work performed by the contributing scientists has made this book a first-class, up-to-date, state of the art review on what is known about whole-body vibration injuries today. The outstanding scientific quality of the abstracts was secured through the review work of scientific committees and organising committee.

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Without the excellent skills of the local organising committee – Christina Ahlstrand abstract and program management, Cecilia Andreasson (administration, layout, and technical editor), Ann-Sofie Liljenskog Hill (administration, economy, and travel) the production of this book would not have been possible. We want to express our gratitude to the contributing authors, session chairs/co-chairs and to the participants who presented papers and contributed in the discussions, for making WBV2017 an outstanding meeting.

Gothenburg in June 2017

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A musculoskeletal spine model for predicting spinal muscle forces of a human body exposed to whole-body vibration

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Vibration transmitted to and through the body may cause degeneration of spinal region; deformations especially occur at the lumbar region [1]. Due to practical and ethical restrictions, in-vivo muscle forces spanning the spine during whole-body vibration cannot be experimentally obtained. To determine the adverse effect of different characteristics of vibration on human spine, biodynamic musculoskeletal models have been developed and analysed iteratively to predict the force sharing among muscles. In some literature, a musculoskeletal dynamic model has been developed to predict muscle forces [2-4]. To assess the risk factor of spinal injury, prediction of muscle forces plays an essential role. It has been reported that muscle forces substantially increase the compression and shear forces on the spine and cause a risk of spinal injury [5].

The aim of this study was to predict the force distribution among muscles crossing the lumbar spine using musculoskeletal simulation software, Opensim. This is an open sourced software capable of analysing multibody musculoskeletal models with a static optimisation method to predict muscle forces [4,6]. In Opensim, which allows to built up various muscle models as well as user defined muscle models, the Hill type muscle model is generally used. Hill type muscle model is implemented as Thelen model in Opensim and adopted in this study [7,8].

For the purpose of this study, a set of biodynamic response data of human body was used for the analysis. The experimental data from a recently published research were measured from a subject sitting upright without backrest exposed random vertical vibration between 0.5 to 15 Hz in 1.0 m/s^2 rms [3]. The accelerations in the vertical and fore-and-aft directions at T5, L3, L5, pelvis and seat were recorded using accelerometers, while the forces in the vertical and fore-and-aft directions were simultaneously recorded at the rigid seat pan with a force plate. A musculoskeletal spine model from Opensim library was modified by scaling the model to the height of the upper body of the subject [9]. The musculoskeletal upper trunk multibody model consists of rigid pelvis-sacrum, L5, L3-L4, L2-L1-torso segments and abdominal, lumbar erector spinae, psoas major, quadrates lumborum and multifidus muscles. The acceleration data were converted to displacements and served as the input to the model for determining kinematic motions of the spine, while the force data were used as the kinetic input to the musculoskeletal spine model. Properties of Hill type muscle models were drawn from literature [6-13]. The objective function of the optimisation was defined as minimising the sum of the squared muscle activations. The muscle forces (based on activation, muscle fibre length and muscle fibre velocity) at each individual location were then predicted during the optimisation procedure. The muscle activation depends on the muscle forces and muscle parameters.

Following the method by Christoph and et. al., suitability of the model was tested by checking if the predicted moment arm of the muscles is within the range of motions physically allowed [9]. The moment arm of the muscles calculated in Opensim is the distance from the muscles to the centre of rotation. The muscle produced torques which are dependent on the moment arm enable the bones to rotate around the joints. The moments arm is a parameter for validating the musculoskeletal model [14].

The predicted muscle forces under the random vibration were mutually compared. The effects of random vibration on the muscles were investigated. The results showed that the maximum force of erector spinae muscle group was larger in Newton scale than the other lower back muscle forces. Since smaller muscle forces were found in the abdominal region than at the lower back, it was deduced that the abdominal muscles group may be negligible in the next step of developing a detailed finite element model of the musculo-skeletal system. The results obtained from this study constitute the first part of the predicted spinal loads. It has also been recognised that in the current study there are two limitations which need to be taken into consideration in the next study: No statistical analysis was performed and the model verification was only performed with experimental data from one subject. Electromyography data may also be used in the future study.

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