VALIDATION OF A BIOMECHANICAL MODEL OF THE LUMBAR SPINE

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INTRODUCTION

Hansen et al [1] and de Zee et al [2] reported on a new and very detailed model of the human lumbar spine. In its current version the model comprises a total of 194 spinal muscle fascicles spanning the pelvis, sacrum, five lumbar vertebrae and the joint between the lumbar and thoracic parts. In addition, the abdominal muscles are included in the model and may contribute to extension via a built-in model of the intra-abdominal pressure. Figure 1 depicts the model.

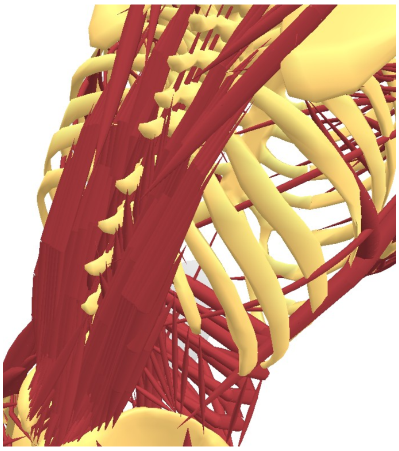

Figure 1: The spine model with muscles crossing the lumbar vertebrae and abdominal muscles on the frontal side.

Validation of musculoskeletal models in general is challenging because muscle forces are very difficult to measure in-vivo. However, a few authors have reported on spinal disk pressure measurements in-vivo. By multiplication with the interface area of between the disk and the vertebra, these may be converted to a measure of the compression force between adjacent vertebrae. Since this force to a large extent results from the muscle actions, it may serve as an indirect validation of the muscle recruitment in the lumbar spine. In this paper we compare computed compression forces between L4 and L5 with measurements of Wilke et al [3].

METHODS

Wilke et al [3] report on in-vivo measurements of disk pressures under different posture and loading conditions. Dennison et al [4] measured linearity between the internal disc pressure and the axial force. The AnyBody Modeling System v. 3.0 (AnyBody Technology, Aalborg Denmark) and its associated library of musculoskeletal models is capable of modeling humans in user-selected postures, movements and external loads and in these situations estimates the muscle forces and joint reactions according to user-selected recruitment criteria.

The redundant muscle recruitment problem is solved by a min/max algorithm according to [5] and [6] and as a result of the process the joint reactions are computed, in particular the reactions in the L4/L5 joint for which disk pressure measurements are available from [3].

RESULTS AND DISCUSSION

Wilke et al [3] specify spinal pressure measurements in pressure units while AnyBody calculates the compression in Newton. To enable direct comparison between these different physical quantities and to account for differences in anthropometric data between the test subject and the model, results are normalized with respect to the standing posture in Figure 2.

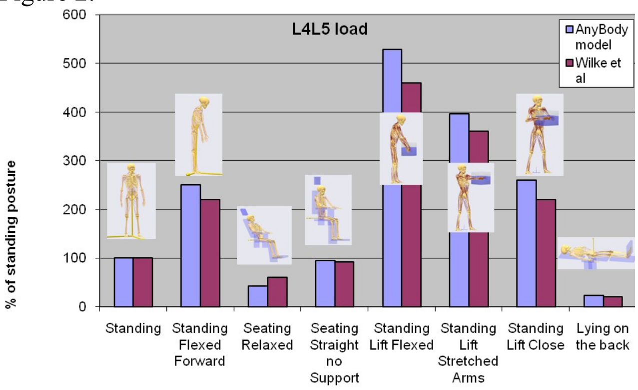

Figure 2: Comparison between measured [3] and computed disk compression forces.

CONCLUSIONS

Figure 2 shows that the correspondence between measured and computed disk joint loads is as good as can be expected when a generic model is used. For the model trustworhtness it is important that the model shows the same trends as the in vivo measurements, because only then the model has predictive value.

The potential of a reliable simulation of spinal forces are multiple within ergonomics, occupational health, design or orthopedic devices and orthopedic surgery in general.

ACKNOWLEDGEMENTS

This work was partially supported by the Danish Research Council for Technology and Production Sciences.

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