A 3-D BIOMECHANICAL MODEL TO CALCULATE LOAD AT THE LUMBOSACRAL JOINT FOR MANUAL LIFTING TASKS

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INTRODUCTION: Low back disorders(LBD) represent a major proportion of health problems, resulting in high costs for employers and placing high demands on health services. One source for LBD is manual lifting and load manipulation in work place situations. With an obligation to occupational safety and health (by national and European law) ergonomists are required to provide guidelines for practioners, which include weight limits for lifting tasks. The present guidelines in use have been developed on a basis of qualitative evaluation and statistical classification of collected data. Amounts of intervertebral disc compression are calculated by 2-D models (Siemens-Burandt in Istanbuli, S., Mainzer, J. (1986); NIOSH in Waters, T.R. et al.(1993); Bundesanstalt für Arbeitsschutz und Arbeitsmedizin in Steinberg,U., Windberg,H.-J. (1997)).
The purpose of this study is to develop a 3-D model, that allows for a quantitative evaluation of load at the lumbosacral joint while in the work place. The model is designed to be easily applicable for the practitioner, without the need of data collection that has the potential to affect the process of production.

METHODS: In the first version of the model, the load is calculated in a static position. The upper trunk and arms (6 rigid segments) can rotate about the three body axes against the lower trunk (7 rigid segments) and legs. The straight arms are reaching for the object to be lifted. The position of the lumbosacral joint in the lower trunk is defined according to Chaffin, D.B., Andersson, G.B.J. (1992). Model input includes anthropometric data (segment length), the 3-D coordinates of joint center positions, and/or body angles for the lifting situation. Inverse dynamics and anthropometric modeling are used to calculate the model output including muscle activity (represented by 6 muscle components) and compression and shear forces (lateral, anterior-posterior) at the lumbosacral joint.
The pilot study included data collection via a standardized Ergonomics questionaire for an industrial work place involved with a high mechanical load. The laboratory work included data collection of EMG signals, ground reaction force, and video taping that allowed a more detailed description of the problem and the model‘s validation in some respects. Further experiments are planned, adding information for a wider range of lifting movements.

RESULTS: First results showed that the compression forces were in agreement with results of other studies (Jaeger, M. et al. (1989)). Calculated shear forces make up to one third of the amount of compression forces and their relevance to LBD has to be discussed, especially with regards to which anatomical structures cause shear forces to produce strain.

CONCLUSION: Although this makes the modeling more complicated, the first results reveal the necessity of adding the third dimension of the lifting movements to the standard evaluation processes of work load. A model that is concerned with more detailed dynamics of the work situation, with varying arm positions and muscle representation, is in consideration for future study on this topic.

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