A BIOMECHANICAL MODEL TO TEST THE EFFECTS OF A PASSIVE EXOSKELETON ON THE SHOULDER COMPLEX

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Introduction

In the last years, wearable passive exoskeletons grew in popularity. Modern devices rely on lightweight springs and cantilevers to exert torques reducing the load on human joints. Typical applications are in rehabilitation or in industry to assist workers during heavy tasks, e.g. overhead tasks. Several possible designs were proposed. Devices meant to be used in working environment need to be lightweight, minimally invasive, easy to use and not to causing discomfort to the user. The aim of this work was to introduce a new detailed model of the shoulder complex and to study the effects on shoulder kinematics of a modern exoskeleton i.e. the "Paexo",by Ottobock (ottobockexoskeletons.com).

Methods

An OpenSim (opensim.stanford.edu) model of the bilateral shoulder complex was implemented. The novelty of this model is in the introduction of a detailed modeling of the scapulo-thoracic joint (Fig. 1). The model was based on a previous one [1].

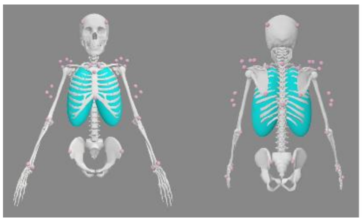

Figure 1 (left): The biomechanical model developed in OpenSim; Figure 2 (right): Arm elevation trial with the exoskeleton.

This preliminary study was conducted on one healthy subject (male, 24 years, 82 kg, 188 cm). The subject was asked to perform a full arm elevation task in the scapular plane, i.e. ~35 deg. rotated from the frontal plane [2]. The test was repeated twice: (i) free and (ii) wearing the exoskeleton (Fig. 2). In each case, the task was repeated five times. The motion was recorded by means of an 8-cameras MotionAnalysis® system (motionanalysis.com) and reflective markers placed on the skin of the subject. The motion of the scapula was tracked by means of a marker cluster fixed on the acromial process plus a calibration procedure based on a static pose as reference. A marker cluster was also added to the upper arm. Gleno-humeral rotation centers were obtained from a functional calibration procedure based on the helical axis method [3]. The anatomical markers were used to scale the model, the tracking clusters were privileged when solving the inverse kinematics. The generalized kinematic coordinates of scapula and humerus where analysed.

Results

The measured kinematics in the free condition matched the findings of previous studies [1,2]. While wearing the exoskeleton, the scapular range of motion was larger in elevation and upward rotation, and smaller in abduction and winging. The scapulohumeral rhythm was also modified.

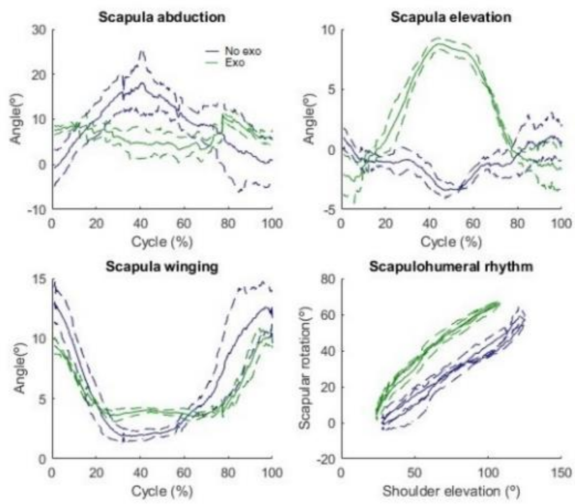

Figure 3. Left scapula coordinates with and without the exoskeleton. Average and standard deviation between repetitions.

Discussion and Conclusion

This work represents a preliminary study on the effects on shoulder kinematics of wearable exoskeletons. The findings suggest a modified motion pattern of the shoulder complex while wearing the exoskeleton. The main limitation is the effect of the soft tissue artifact [4] on the shoulder markers that reduces the accuracy of scapula tracking. Another limitation is the use of a generic skeletal model that may not accurately match the anatomy of the subject. Further studies will require to refine scaling, a larger number of subjects and the analysis of kinetics (dynamics).

References

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