Task Specific Maximal Elbow Torque Model For Ergonomic Evaluation

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INTRODUCTION

In industrialized and developing countries, musculoskeletal disorders (MSD) represent the principal cause of working day loss. Most of them affect the upper limb. Risk factors identified include load, repetition, and postures [1]. While distinct indices exist to assess independently these factors none account for their interaction.

In production lines, some operations remain manual because of reduced workspaces and require workers to adopt unnatural postures while producing efforts. Since loads and postures management are dependent within the musculoskeletal system, measures able to relate them are required.

Isokinetic measurements were proposed to assess the maximal load capacity within joint. The purpose of this study was to evaluate the physical demand during an overhead manipulation task. A ratio between elbow flexion torque during the task and maximal isokinetic torques obtained in a similar posture was computed. Our hypothesis is that the ratio will be higher than 10% (i.e. 2 on Borg scale), meaning that fatigue related to the task should be considered for task management planning [2].

METHODS

Task measurement

The task consisted in holding and pushing up a screw-gun with the arm in 90° flexion to reach a point located 2 meters above the ground. A set of 47 anatomical markers put on the entire body as in [3] were recorded during the task using a 16 cameras motion capture system at 100 Hz. Simultaneously, ground reaction forces and moments were measured using two AMTI 120x60 cm force platforms at 1000 Hz supporting each foot. Inverse kinematics and inverse dynamics were performed using a full body model in Anybody to obtain joint angle, velocity and torque during the task. The model is available at the AnyBody Managed Model Repository[1].

Isokinetic measurements

The dynamometer was set up with the participant laying on the table and his dominant arm elevated in 90° flexion. Maximal isokinetic elbow flexion measurements included concentric and eccentric cycles at $60°.s^{-1}$, $120°.s^{-1}$, and $180°.s^{-1}$. Three maximal isometric measurements were also recorded at varying elbow angles. Between trials, 1-minute rest was respected. Using the method in [4] based on Hill muscle model, parameters of the elbow flexion torque-angle-velocity relationship were optimized to fit the isokinetic data.

RESULTS AND DISCUSSION

The maximal torque model (Fig.1a) obtained elbow parameters values in coherent with those found in the literature [2]: maximal torque 38 $N.m^{-1}$, optimal angle 60°, range of motion 222°, 50% at $720°.s^{-1}$, 75% at $585°.s^{-1}$, concentric/eccentric ratio 0,13. With the arm in 90° flexion, the elbow flexion optimal angle and maximal torque of the participant seems smaller than in a more natural posture.

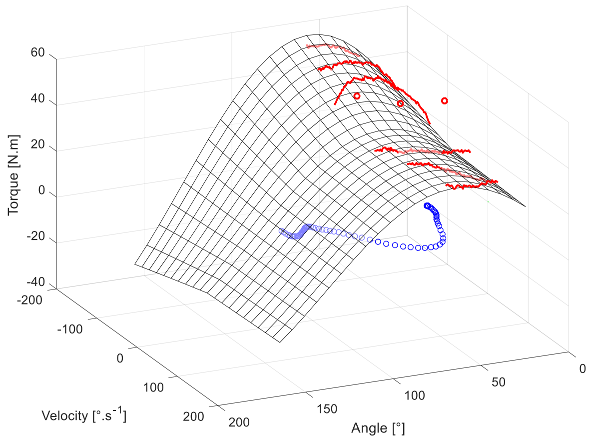

Figure 1: The torque-angle-velocity relationships during the task (dots) compared to the maximal torque model (mesh) fitted to the isokinetic experimental data (bold lines).

With regard to the limits defined by this model, the elbow flexion torque during the task varies about 10% of maximal torque in average with a maximal peak at 20% (Fig.1b). This peak seems to be obtained at the moment the screw-gun reaches the pushing position. These ratios refer to a “somewhat hard effort” [2]. Therefore, a proper task management planning should take this information into account. In addition, the task can be expected to impose higher loads on the shoulder joint. The same protocol might require to be applied on shoulder flexion and

CONCLUSIONS

Overhead manipulation tasks could be considered as “a somewhat hard effort” for elbow flexion. However further research is required on the shoulder to complete this evaluation. In the future, the present method could easily be applied to various type of tasks.

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