COMPARISON OF TWO METHODS OF DETERMINING RELATIVE EFFORT DURING SIT-TO-STAND

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INTRODUCTION

Older adults have a reduced ability to perform activities of daily living (ADLs), and one possible reason is older adults perform ADLs at a higher level of relative effort compared to young adults. Relative effort has been quantified by expressing joint torques during an activity as a percentage of the maximum voluntary torque (Hortobagyi 2003).

Anderson et al. (2007) developed a model to predict maximum voluntary joint torque as a function of joint angle and angular velocity using a regimen of isokinetic and isometric measurements. This model could be used to estimate maximum voluntary torque when assessing relative effort.

The main purpose of this study was to compare two methods of determining relative effort during sit-to-stand (STS). It was hypothesized that relative effort values that account for variations in maximum voluntary joint torque with joint angle and angular velocity will be higher than relative effort values that do not account for these variations.

METHODS

Thirty participants (mean 43.5 ± 21.6 years) performed six STS trials at three self-selected speeds (slow, normal, fast). Participants rose from an armless, backless chair that was positioned on a forceplate with feet spaced shoulder width apart and each resting on a forceplate.

Sagittal plane joint torques in the right lower extremity were estimated using a 2-D rigid-link model. Body segment data was sampled at 100 Hz (Vicon, CA) and force plate data were sampled at 1000 Hz. Isometric and isokinetic maximum voluntary contractions (MVC) for knee extension were collected using a Biodex System 3 dynamometer and used for model parameters to predict the participant-specific theoretical maximum voluntary joint torque (Anderson 2007).

Two methods were used to calculate relative effort (Figure 1). Method 1 (M1) first determined the peak joint torque during STS, then normalized this torque by dividing it by the maximum isometric torque recorded from the Biodex. Method 2 (M2) first normalized joint torques throughout STS by dividing each instantaneous value by the theoretical maximum voluntary joint torque at the specific joint angle-angular velocity combination, then determined peak relative effort.

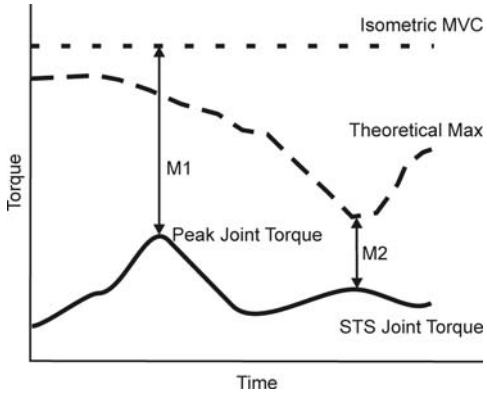

Figure 1: Sample STS data to illustrate the two methods of calculating relative effort.

A two-way ANOVA was conducted on relative knee extension effort with method (M1 or M2) and speed (slow, normal, or fast) as independent variables.

RESULTS AND DISCUSSION

Relative knee extension effort showed main effects of speed ($p<0.001$), method ($p<0.001$), and a speed x method interaction ($p<0.001$) (Figure 2). Pair-wise comparisons between speeds revealed the relative effort at a fast speed (82.5 ± 31.8%) was higher than at a normal speed (66.8 ± 23.0%), and both were higher than at a slow speed (45.5 ± 13.4%). Pair-wise comparisons between methods revealed the relative effort calculated using M2 (78.4 ± 32.1%) was higher than M1 (51.7 ± 15.0%). Pair-wise comparisons to evaluate the speed x method interaction revealed relative effort calculated using M2 increased at a higher rate as speed increased compared to relative effort calculated using M1.

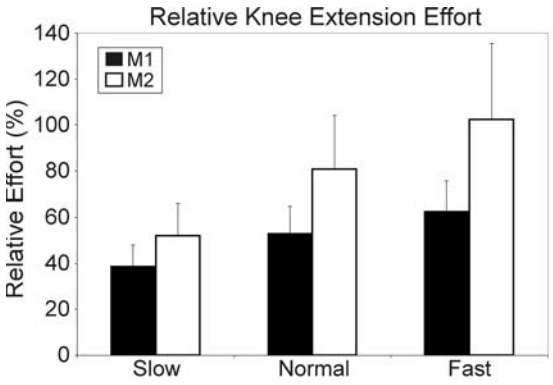

Figure 2: Mean relative knee extension effort during STS for all three speeds and both methods. Error bars represent standard deviation.

In general, accounting for variations in maximum voluntary joint torque with joint angle and angular velocity led to higher levels of relative effort compared to methods which do not account for these variations.

At higher velocities, the difference in calculating relative effort with respect to isometric MVC or incorporating joint angle and angular velocity becomes more evident. The difference between M2-M1 was significantly higher in the fast STS trials than in the slow trials. These results support the importance of including angular velocity in a model when calculating relative efforts during tasks with higher velocities.

SUMMARY/CONCLUSIONS

In conclusion, incorporating variations in joint torque production with joint angle and angular velocity was shown to have an effect on calculated relative effort, especially for tasks with higher velocities.

REFERENCES

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