Analysis of moment corrections in dynamic plantarflexion contractions using dynamometry

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Summary

In vivo determination of the muscle force-length-velocity relationship is typically based on dynamometry. The necessity to correct measured moment has been pointed out previously. However, an investigation of the effect of single corrections on measured moment during dynamic plantarflexions is lacking. We studied the effect of moment corrections at five angular velocities ranging from 45°/s to 270°/s and at three soleus muscle activation levels. We found prominent changes in the contribution of the dynamometer adapter inertial moment and in the contribution of the joint axis misalignment across angular velocities and muscle activation levels. This posits a strong necessity to account for these two often neglected corrections during dynamic plantarflexions.

Introduction

In vivo determination of the muscle force-length-velocity relationship is typically based on dynamometry. Although previous studies have mentioned the need to correct the measured moment to assess the active joint moment [1,2], this is often not done. Furthermore, the interaction of different moment corrections during dynamic plantarflexion contractions has not been previously reported. The objective of the study was to evaluate the effect of single moment corrections on measured ankle joint moment at different angular velocities and muscle activation levels.

Methods

Eleven participants (3F/8M) performed maximal and submaximal plantarflexions in the prone position on an isokinetic dynamometer with the knee flexed at 110° to exclude the contribution of the biarticular gastrocnemii muscles. Ankle joint and dynamometer kinematics as well as the electromyographic activity (EMG) of the soleus muscle were recorded. Five angular velocities (45°/s, 90°/s, 150°/s, 210°/s, 270°/s) and three activation levels ($\hat{a}_{max}, \hat{a}_{60}, \hat{a}_{30}$) were studied. At each angular velocity, participants performed a set of three maximal plantarflexions and three sets of 10-12 submaximal plantarflexions guided by biofeedback. The EMG was normalized to its angular velocity-specific maximum, and the first-order differential equation proposed by Zajac [3] was used to assess muscle activation $\hat{a}$.

The contribution of the dynamometer adapter gravitational T_{gravi} and inertial T_{inert} moments, the contribution of the misalignment between the dynamometer and ankle joint axes T_{axis} as well as the contributions of passive ankle joint moment T_{pass} and the foot gravitational and inertial moments T_{foot} to measured moment were calculated.

Results and Discussion

Differences between measured and active joint moments were in average 14.9, 14.6, 19.2, 23.8 and 22.8% for five angular velocities respectively (range 0.03-70.9%). The overall correction affected the time instants of peak moments (Figure 1). Active joint moment peaks were reached earlier and had lower variability.

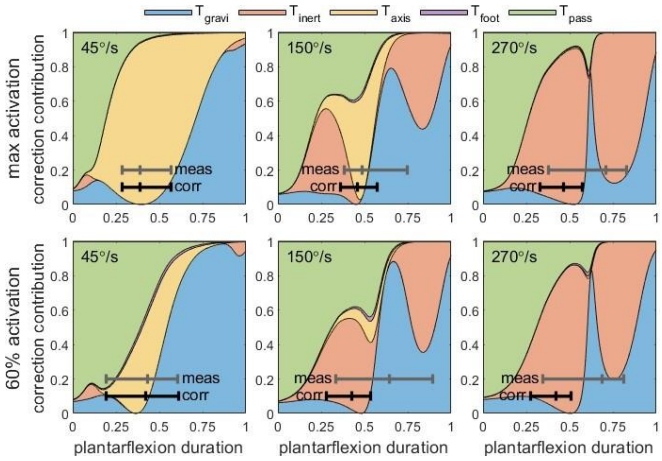

Figure 1: Contribution of moment corrections at three angular velocities and two activation levels. Whiskers denote the ranges of the time instants of measured and corrected moment peaks.

T_{inert} and T_{axis} were most affected due to angular velocity and activation level (Figure 1). The contribution of T_{inert} increased with angular velocity ($\hat{a}_{max}$: 0.07 to 0.91, $\hat{a}_{60}$: 0.08 to 0.86, $\hat{a}_{30}$: 0.11 to 0.52). The contribution of T_{axis} decreased with an increase in angular velocity and with a decrease in muscle activation ($\hat{a}_{max}$: 0.95 to 0.01, $\hat{a}_{60}$: 0.5 to 0.02, $\hat{a}_{30}$: 0.06 to 0.01). The contribution of the other three corrections changed less prominently across angular velocities and muscle activation levels.

Conclusions

We posit a necessity of moment corrections during dynamic plantarflexions. Especially, the widespread neglecting of the axis misalignment and the dynamometer adapter inertial corrections would lead to the erroneous assessment of the magnitudes and time instants of peak moments.

References

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