REVISITING THE EMG-TORQUE RELATIONSHIP OF THE TRUNK MUSCULATURE: EFFECTS OF ANTAGONISTIC CO-CONTRACTION

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INTRODUCTION

The use of electromyographic signals in the modeling of muscle forces and joint loads requires an understanding of the relationship between the acquired electrical signals and their generated joint torques. This relationship has been studied for the trunk extensor musculature and predominantly been shown to be non-linear (Stokes et al., 1987; Potvin et al., 1996), with a reducing increase in torque output for a given increase in electrical activity. This relationship has been studied very limitedly in the abdominal musculature (rectus abdominis only), with similar results (Stokes et al., 1989). However, in neither case has the effect of torque produced by muscles acting antagonist to the dominant moment been thoroughly considered. Thus, the purpose of this study was to reveal the sensitivity of the EMG-torque relationship of the trunk musculature to the consideration of antagonist muscle torque.

METHODS

Eight healthy male individuals sat with knees supported and a harness secured across the upper torso and attached to a wall. Participants were instructed to slowly generate either isometric extensor or flexor trunk torques from rest to maximum and back to rest. This was done both with an upright neutral torso, and with the torso flexed to 50% of maximum about the hips. EMG was recorded from 6 bilateral abdominal muscles and 8 bilateral extensor muscles. EMG was rectified, LP filtered (2.5 Hz) and, using an anatomically detailed biomechanical model, an estimation was made of the torques generated by both the extensor and abdominal musculature. The agonist muscle torques (abdominal muscles in the flexor condition and back muscles in the extensor condition) were then either linearly or non-linearly normalized to maximum and compared (RMS difference) to: 1) externally calculated torque alone; 2) externally calculated torque combined with antagonist muscle torque.

RESULTS AND DISCUSSION

A great deal of co-activation between the abdominal and extensor muscle groups occurred in each condition. Thus, the degree and form of non-linearity in the EMG to torque relationship depended heavily on whether or not antagonist muscle activity was considered. When antagonist activity was not considered the relationship was slightly non-linear, similar to previous work (Stokes et al., 1987; Potvin et al., 1996). The relationship was consistently more non-linear when torques were generated in the 50% flexed posture, and consistently more non-linear in the abdominal as compared to the extensor muscle groups. However, when the additional muscle torque generated by the antagonist muscle groups was accounted for, the relationship became much more linear, displaying only very slight non-linearities.

Most striking, these slight non-linearities were opposite to those previously found experimentally, with rising increases in torque outputs for a given increase in electrical activity. It is interesting to note that this opposite non-linear form has been theorized using motor unit driven models of EMG (Milner-Brown & Stein, 1975; Fuglevand et al., 1994). Figure 1 displays the EMG-FlexorMoment (50% hip flexion) relationship in both cases: where antagonist muscle activity has not (A) and has (B) been accounted for.

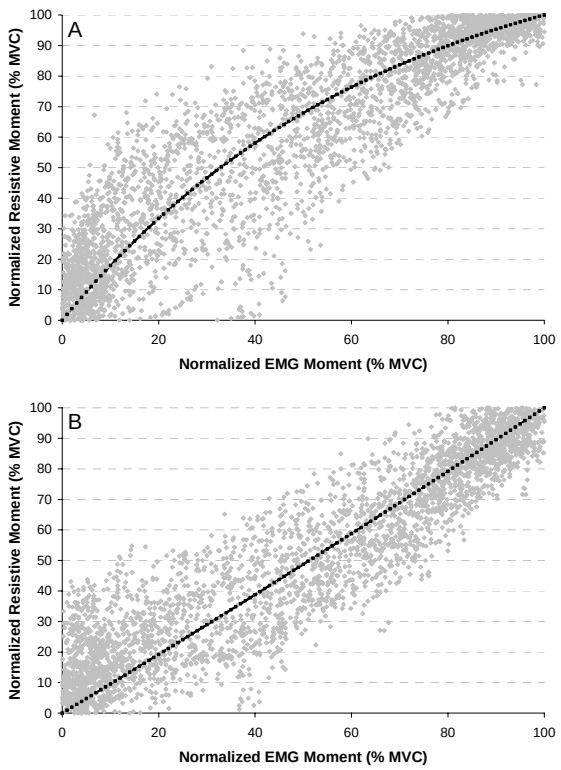

Figure 1: Scatterplots (all participants and trials) for the Flexor Moment 50% flexed condition displaying the Agonist EMG Moment normalized to 100% of maximum versus the Resistive Moment normalized to 100% of maximum. A: Resistive Moment is the externally calculated moment alone; B: Resistive Moment is the combined externally applied moment and antagonist muscle moment.

Finally, the non-linear differences between abdominal and extensor muscle groups were reduced when antagonist activity was accounted for.

SUMMARY/CONCLUSIONS

Proper modeling of the EMG-torque relationship of the trunk musculature requires consideration of the activity of both agonist and antagonist muscles, at least for the type of isometric exertions studied here. This study suggests that the relationship is primarily linear, and that non-linear impressions are most likely due to disproportionate antagonist activity as torso muscles increase force. It also appears that very little difference exists between the EMG-torque relationship between the trunk extensor and abdominal musculature; therefore they can be treated in a similar manner during the EMG processing stage.

REFERENCES

Fuglevand, A.J. et al. (1993). *J. Neurophysiology*, **70**, 2470-2488.

Milner-Brown, H.S., Stein, R.B. (1975). *J. Physiology*, **246**, 549-569.

Potvin., J.R. et al. (1996). *Eur. J. Appl. Physiol.*, **74**, 119-132.

Stokes, I.A. et al. (1987). *Spine*, **12**, 770-776.

Stokes, I.A. et al. (1989). *Spine*, **14**, 857-861.