

MUSCLE ACTIVATION PATTERNS CHANGE THE INHERENT STIFFNESS OF THE HUMAN TRUNK

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INTRODUCTION

The torso musculature is quite unique in its anatomical arrangement. In particular, the abdominal wall muscles (external and internal obliques, transverse abdominis) overlay each other in a sheet-like formation and act through attachments to the abdominal and thoraco-lumbo-dorsal fascias to create a hydraulically pressurized abdomen

Most of what we know about muscle stiffness has been obtained from studies of the long strap-like muscles of the limbs. The abdominal wall muscles, however, may not be expected to stiffen in an entirely similar manner given their distinctive architecture. In fact their ability to stiffen may be enhanced through a hydraulic mechanism, modifying intra-abdominal pressure and transferring hoop stresses around the torso (Farfan, 1973).

To date, no study has attempted to quantify the trunk stiffness inherent at varying levels of trunk muscle activation. This may elucidate the role of torso muscle activation on the hydraulic stiffening mechanisms discussed above. Therefore, the purpose of this study was to examine trunk stiffness related to torso, and in particular abdominal, muscle activation levels, in the absence of muscle reflexes.

METHODS

Nine healthy males volunteered for this study.

Each participant was secured to a jig that eliminates measurable friction and allows trunk movement about either the flexion-extension or lateral bend axis, depending upon how the participant is secured. Participants lied on their right side for the flexion-extension trials, and on their back for the lateral bend trials. Participants were then instructed to maintain one of four torso activation patterns: relaxed (minimal activation); activate EMG biofeedback (placed over the right external oblique) to 5 % MVC (light brace); activate biofeedback site to 10 % MVC (moderate brace); activate biofeedback site to 20 % MVC (heavy brace). Participants were instructed to tighten their abdominal muscles isometrically in order to achieve the desired brace levels. EMG was monitored from 14 torso muscles.

Once each participant had achieved their target activation pattern during each trial, the experimenter applied a torque such that the participant's upper body rotated (isolated at the pelvis) in the desired direction (flexion, extension, or right-side lateral bend) at a relatively constant velocity.

3-Dimensional lumbar trunk motion was recorded using an electromagnetic tracking system (Isotrak, Polhemus, Colchester, VT, USA). The moments applied to the torso were recorded by the product of the force applied perpendicular to the distal end of the upper body cradle (measured via a force transducer) and the moment arm from the location of the applied force to the level of L4/L5.

Moment-angle curves were developed and exponential curve fits of the following form were performed for each brace level/direction combination:

$$M = \lambda e^{\delta\phi} \quad (1)$$

This equation was differentiated once with respect to ϕ to obtain a measure of trunk angular stiffness:

$$K = \lambda\delta e^{\delta\phi} \quad (2)$$

RESULTS AND DISCUSSION

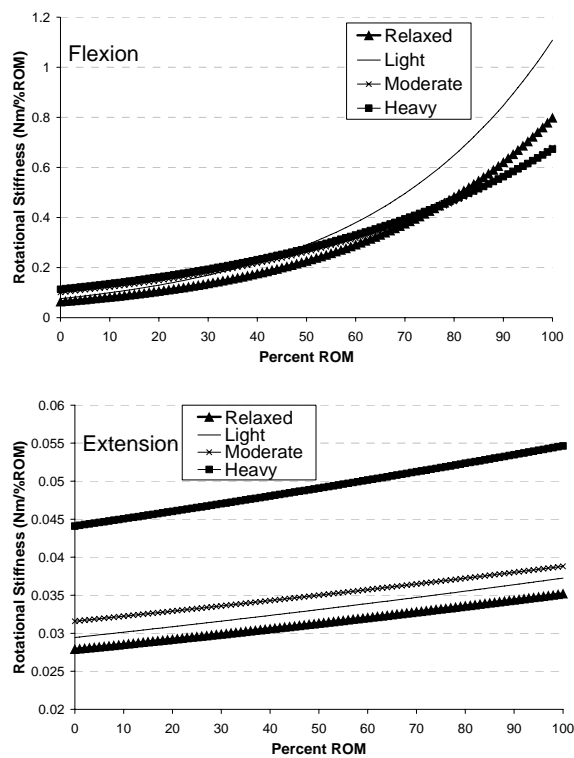


Figure 1: Stiffness (Nm/%ROM) across the ROM in each of the flexion and extension directions.

Stiffness increased exponentially at each muscle activation level in both flexion and lateral bend (Figure 1).

In flexion, from zero to approximately 40% ROM, stiffness increased with each level of abdominal brace; in lateral bend, this trend existed from zero to approximately 60% ROM. Above these ROMs higher levels of

activation actually resulted in a lower stiffness level than less active states (Figure 1 flexion).

Extension stiffness, however, showed an increasing linear trend with increasing ROM for each of the muscle activation levels, and stiffness increased with each successive increase in trunk muscle activation (Figure 1).

SUMMARY/CONCLUSIONS

The ability of increasing torso, and in particular abdominal, muscle activation to increase trunk stiffness is partially dependent upon trunk posture. In extension, spine stiffness increased with successive increases in muscle activation throughout the ROM. Similarly, in trunk postures most commonly adopted by individuals through daily activities (neutral to approximately 40% of maximum) spine stiffness increased in the flexion and lateral bend directions as muscle activation increased. However, towards the end ROM in both flexion and lateral bend, individuals became less stiff at the maximum abdominal muscle co-activation levels. We have previously documented similar findings whereby trunk stiffness is somewhat compromised at high levels of co-activation (Brown et al., 2006). The source or mechanism of this phenomenon is still not yet clear; future work will be directed to uncover the cause

REFERENCES

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