EFFECT OF TRUNK POSITION ON SPINAL LOADING DURING ANGLED ROWS

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INTRODUCTION
Vertebral fractures are common in older age, particularly in women, and are associated with profound detriments to quality of life [1]. Exercise that applies large loads to the spine may aid in preventing such fractures. Of note, training programs that included rowing exercises have shown osteogenic benefits [2], and young female rowers exhibit increased spinal bone density [3]. However, little is currently known regarding the effects of variations in row technique on spinal loading. This study therefore examined the effects of trunk position on the loading at two different spinal levels during angled row exercises performed during standing.

METHODS
Participants were five healthy, premenopausal women (mean ± SD age: 43 ± 3 years, mass: 60 ± 6 kg, height: 165 ± 3 cm) experienced in upper-body strength-training exercises. After informed consent and a task-specific warm-up, 32 reflective markers were placed on participants’ trunk and limbs. They then performed standing rows against a target peak resistance of 111 N from elastic tubing (Black Mountain Products, Lakemoor, IL). A set of 3-4 angled rows, with the tubing angled upward at 45° from the floor, was performed in each of two trunk positions: erect and flexed 30° from vertical. Participants smoothly pulled the tubing’s handles to their chest in ∼1 s, and after minimal pause, reversed this motion. Rows with the trunk flexed were in a squatted position. A motion capture system (Vicon, Culver City, CA) and two force plates (Bertec, Columbus, OH) recorded kinematic and ground reaction data at 60 Hz and 360 Hz, respectively. Body dimensions and weight were also taken.

Motion capture and force plate data were filtered at 7 Hz and 14 Hz, respectively. Marker positions relative to body segments and joint centers were calculated (BodyBuilder, Vicon). From the data, the AnyBody Modeling System (Aalborg, Denmark) then computed the compressive and anteroposterior (AP) shear forces at T12/L1 and L5/S1. The model was scaled to each participant, and inverse dynamics solutions were found to minimize the sum of the cubed muscle fascicle activations. Spinal forces at the row midpoint (i.e. at peak tubing length) were extracted, normalized to body weight, and averaged across trials.

Repeated-measures ANOVA, with post-hoc paired t-tests, was used to identify effects of trunk position (erect vs. flexed) and spinal level (T12/L1 vs. L5/S1) on the mean compressive and AP shear force magnitudes at the row midpoint. p<.05 was used for statistical significance.

RESULTS AND DISCUSSION
The effect of trunk position on the compressive force acting at the midpoint of the angled rows differed between spinal levels (p=.002; Figure 1). At L5/S1, the compressive force at the row midpoint was larger for rows in the trunk-flexed than in the trunk-erect position (p=.006), whereas at T12/L1, this compressive force did not differ between trunk positions.

Figure 1: Mean values of compressive and AP shear force magnitudes at the row midpoint for each trunk position and spinal level. Error bars correspond to 1 SD. *p<.01 for erect vs. flexed, †p≤.01 for L5/S1 vs. T12/L1. BW=body weight.

Across both spinal levels, the AP shear force at the midpoint of the rows was larger in magnitude in the trunk-flexed than in the trunk-erect position (p=.003; Figure 1). Regardless of trunk position, the shear force magnitude was also larger at T12/L1 than at L5/S1 (p=.001). However, this shear force was directed anteriorly onto L1, but posteriorly onto S1.

The present results make sense. With the trunk flexed, the moment arm, and hence moment of the head-arm-tORSO weight about L5/S1 is larger, necessitating more offsetting force from the lumbar extensors, thereby increasing spinal loading at L5/S1. This effect would be seen less at higher spinal levels. Also with the trunk flexed, the spine is tilted anteriorly, altering the direction of the head-arms-tORSO weight relative to the spine such that it will create less compressive, but more anterior shear force onto L1. Greater compression may be of osteogenic benefit to the vertebral bodies, but increased shear may place the intervertebral discs, ligaments, and/or facet joints at greater risk of injury.

CONCLUSIONS
Performing angled row exercises with elastic tubing while standing in a trunk-flexed instead of an erect position may improve osteogenic compressive stimuli to L5/S1, but not T12/L1. The associated increase in shear force at both joints may also be of concern for high tubing resistances.

REFERENCES

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