BIOMECHANICAL EVALUATION OF SUPPORTED STANDING WITH DIAGONAL REACH

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INTRODUCTION

Low back pain has been reported in association with forward bent and twisted trunk postures in standing[1]. To reduce loading on the spine, assistive devices, such as the Personal Lift Assistive Device have been investigated and shown to be helpful[2]. The Dynamic Trunk Support (DTS) is an alternate type of device that is external, similar to a chair postures (Figure 1). The DTS is designed to provide continuous partial support which makes it suitable for both static and dynamic trunk postures depending on the type of work activity. The objective of the DTS is to reduce compressive lumbar spine loading as well as postural trunk muscle work rather than eliminate through passive positioning. The contact point is the upper ribcage which maximizes the distance where weight is transferred and the lumbar spine. In a previous study, the DTS reduced back and hip extensor muscle activity by an overall average of 60% with static forward flexed trunk angles in 10 degree increments between 10 and 40 degrees[3]. In comparison, leaning against a desk resulted in no change in muscle activity[3]. The purpose of this study is to test the biomechanical effects with dynamic trunk postures that are associated with extreme reaching.

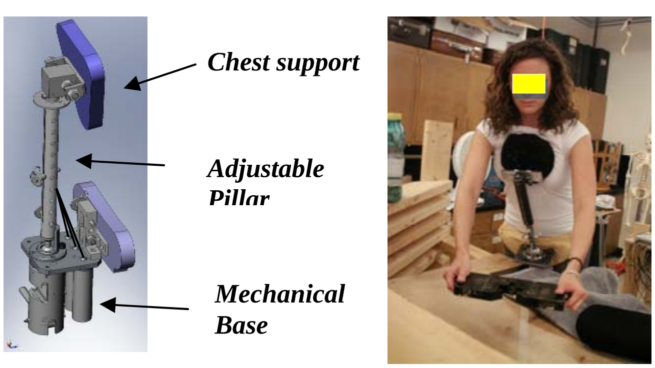

Figure 1: The Dynamic Trunk Support has 3 components; mechanical base, pillar and support. The mechanical base is designed to move in 3 directions. The support transfers weight through the upper 3 ribs and upper half of the sternum.

METHODS

Ten females, with an average age of 30.5 years (SD 9.2) and who gave informed consent, lifted a 5kg three times with 2 hands to a fixed distance (57cm) on a 45-degree diagonal to the left at the height of the pelvis under three conditions: no support, leaning on the desk (normalized to the height of the anterior pelvic crest) and leaning on the DTS with the contact point at the upper half of the sternum). A Fastrak™ (Polhemus, Colchester, VT, US) human motion system was used to continuously collect changes in the position of the trunk, right arm, and right lower extremity. The trunk was divided into three sections. The absolute trunk angles in three dimensions that match with the peak upper thoracic flexion angle are compared. These angles correspond to the maximal reach distance. An 8 channel EMG (Bortec Biomedical, AB, CAN) was used to collect muscle activity from bilateral L5 erector spinae, gluteus maximus and right hamstring. The right upper and lower trapezius muscle was also monitored but results aren't presented here. Muscle activity was calibrated to maximal voluntary contraction with peak values compared. An AMTI force platform (AMTI, Watertown, MA, US) was used to record changes in center of pressure. Moments were calculated using an upwards link segment model. Repeated measure ANOVA tested for differences.

RESULTS

Leaning on a support resulted in a significant reduction of forward flexion of the upper and lower with a 10 degree reduction of the average. Leaning on the desk resulted in a significant reduction in lumbar spine and pelvis rotation (approx 7-10 degrees). Leaning on the DTS resulted in no change to rotation but a small decrease in peak side flexion (Figure 2). Muscle activity was significantly reduced for supported reaching in comparison to no support with a 17% average average reduction while leaning on the DTS and 28% reduction while leaning on the desk (Table 1).

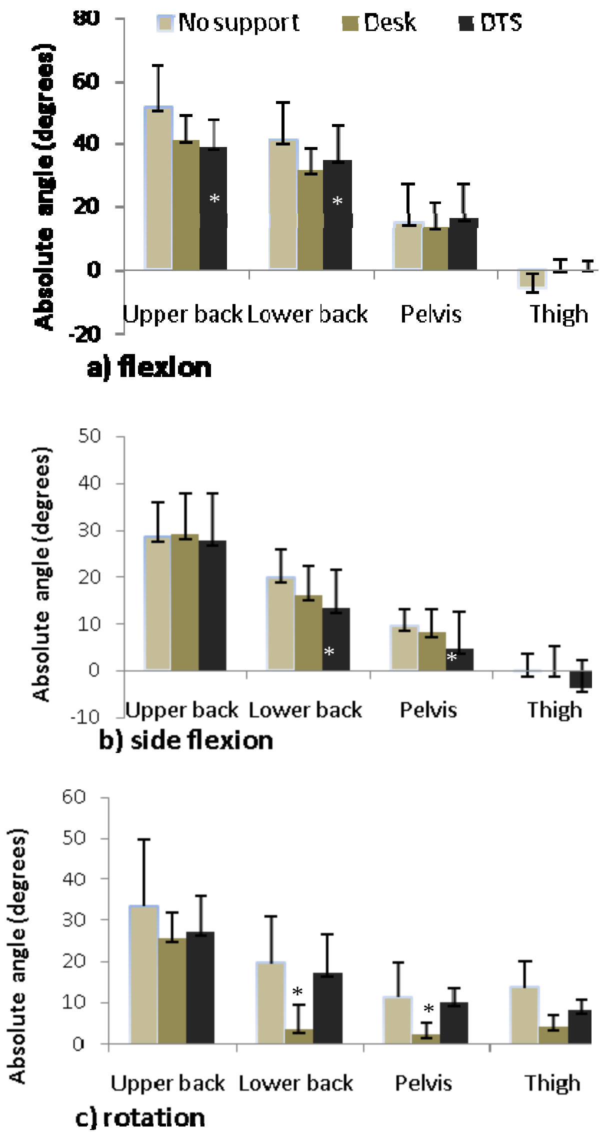

Figure 2: Absolute angles at maximal reach distance corresponding to picking up weight; flexion (a), side flexion (b) and rotation (c).

The changes in center of pressure position at maximal reach were significantly different between conditions with only a small change occurring while leaning on the DTS (Figure3).

	LES		Gluteus Max		Hamstring	
No support	34.5	(12.5)	10.6	(3.6)	11.1	(7.4)
Desk	25.0	(8.1)	8.8	(3.2)	8.8	(3.9)
DTS	28.4	(10.6)	8.0	(3.0)	9.4	(4.2)
	p=0.001		p=0.03			

Table 1: EMG on right side in %MVC.

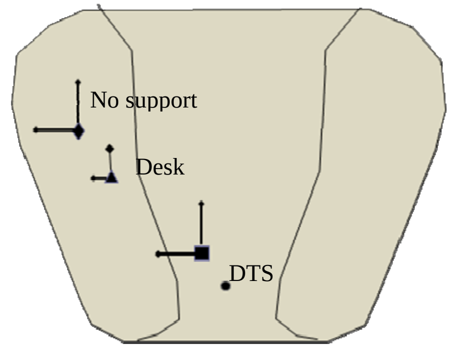

Figure 3: Changes to center of pressure position at maximal reach.

Leaning on the desk, reduces the 3-dimensional moment on the hip however it increases the lumbar spine rotation moment. Leaning on the DTS, reduces both spinal and hip moments without increasing the spinal rotation moment (Table 2).

	No support	Desk	DTS
L4/L5			
Flexion moment (Nm)	166.69 (3.79)	156.04 (4.06)	152.88 (3.1)
Lateral moment (Nm)	172.98 (4.13)	158.95 (3.86)	163.54 (4.1)
Twist moment (Nm)	17.21 (1.38)	18.51 (1.23)	14.94 (2.1)
Hip			
Flexion moment (Nm)	152.36 (3.32)	130.87 (2.23)	114.51 (2.39)
Lateral moment (Nm)	156.75 (3.96)	139.36 (3.83)	118.75 (3.25)
Twist moment (Nm)	16.58 (1.49)	18.49 (1.03)	15.36 (1.15)

Table 2: 3D moments for hip and L4/5. Repeated measure ANOVA presenting the main effects that were significant for at least one of the dependent variables (0.001).

DISCUSSION

Both supported postures reduced the postural muscle activity of the trunk suggesting that the longer reach distance associated with leaning forward is an important variable for consideration with standing work. Using the DTS for support appears to be favorable since it does not result in additional rotational moment at the lumbar spine which could contribute to an increased risk for back injury.

REFERENCES

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