

TRUNK MUSCLE ACTIVATION AND LOW-BACK LOADING DURING THE PERFORMANCE OF STANDARD AND SUSPENDED PUSH-UP EXERCISES

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INTRODUCTION

Push-up exercises are normally performed to challenge muscles that span upper extremity joints. However, it is also recognized that such exercises provide an effective means by which to challenge muscles of the “core”, especially when the hands are in contact with a labile support surface (Freeman et al., 2006). The purpose of this study was to compare trunk muscle activation levels and resultant low-back loads when standard push-ups (STAN) and suspended push-ups (SUS) were performed (Figure 1). It was hypothesized that variables of interest would differ between the push-up exercise variants.

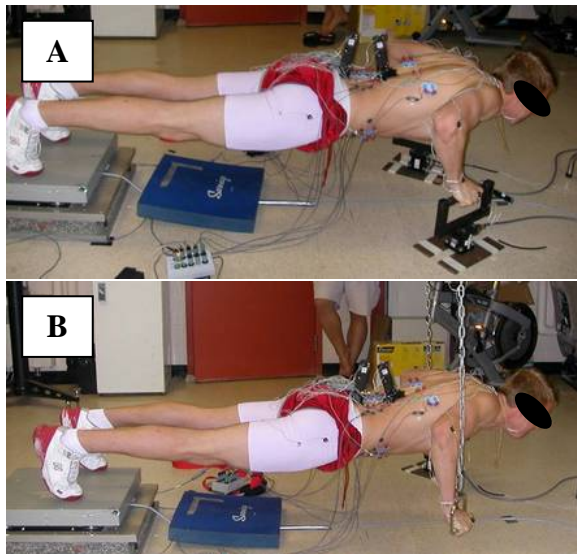


Figure 1: Bottom position of (A) standard and (B) suspended push-up exercises.

METHODS

Eleven recreationally trained male volunteers performed sets of STAN and SUS. Initial postures and the repetition rate were standardized to permit direct comparisons between exercises. The order of performance was randomized.

Surface EMG signals collected from seven bilateral trunk muscle groups (Table 1) were linear enveloped (Brereton and McGill, 1998) and normalized to peak activity levels achieved during maximal voluntary contractions (MVC).

A motion capture system (Optotrak Certus, Northern Digital Inc., Canada) provided upper body position data, and forces acting at the hand-handle interface were measured. These data were inputs for a 3D inverse dynamic linked-segment model (LSM) of the upper body to compute net L4/L5 reaction kinetics.

LSM outputs were used in conjunction with an anatomically detailed EMG-driven 3D model of the lumbar torso (Cholewicki and McGill, 1996) to estimate trunk muscle forces and subsequently L4/L5 joint contact (compression and shear) forces.

Repeated measures analyses of variance (general linear model) were used to compare dependent variables between exercises, phases (up vs. down), and where applicable, between sides of the body.

RESULTS AND DISCUSSION

When performing SUS, muscles of the abdominal wall and the latissimus dorsi were activated to levels that were significantly greater than those elicited when performing STAN (Table 1). No bilateral asymmetries in muscle activation levels were detected (Table 1). As a direct result of these increased activation levels, model-predicted muscle forces increased and consequently led to significantly greater L4/L5 compressive ($p = 0.0001$) and anterior/posterior (A/P) shear ($p = 0.0306$) forces when performing SUS. In a similar vein, muscle activation levels tended to be greater in the up-phase of both exercises (Table 1), and it followed that L4/L5 compressive ($p = 0.0391$) and A/P shear ($p = 0.0281$) forces were significantly greater in this phase of each exercise. The L4/L5 compressive loading response is encapsulated in Figure 2.

SUMMARY/CONCLUSIONS

In comparison to STAN, SUS appear to provide a superior abdominal muscle challenge. However, for individuals unable to tolerate high low-back compressive or shear loads, benefits gained by incorporating SUS into their training regimen may be outweighed by the potential risk of overloading low-back tissues.

Table 1: Mean (SE) trunk muscle activation levels elicited (% MVC). RA – rectus abdominis; EO – external abdominal obliques; IO – internal abdominal obliques; LD – latissimus dorsi; T9 – upper erector spinae; L3 – lower erector spinae; L5 – multifidus surrogate.

	EXERCISE			PHASE			SIDE		
	Standard	Suspended	<i>p</i> -value	Up	Down	<i>p</i> -value	Left	Right	<i>p</i> -value
RA	13.9 (3.9)	39.5 (10.1)	0.0025	28.8 (8.8)	24.6 (8.4)	0.0342	23.9 (7.2)	29.5 (9.8)	0.5466
EO	18.2 (3.8)	26.6 (4.3)	0.0042	25.0 (4.4)	19.7 (3.9)	0.0030	23.5 (4.0)	21.3 (4.5)	0.1345
IO	15.6 (3.8)	24.1 (4.2)	0.0005	21.5 (4.6)	18.2 (3.7)	0.1687	20.1 (4.3)	19.6 (4.1)	0.9075
LD	7.1 (1.4)	11.3 (1.8)	0.0102	9.6 (1.6)	8.8 (1.8)	0.2951	9.8 (1.4)	8.6 (1.9)	0.3703
T9	11.7 (2.2)	12.5 (2.3)	0.5909	14.1 (2.5)	10.1 (1.8)	0.0163	11.0 (1.9)	13.2 (2.5)	0.3029
L3	2.2 (0.6)	4.6 (1.6)	0.0929	3.8 (1.5)	3.0 (1.0)	0.2814	3.8 (1.3)	3.0 (1.3)	0.3665
L5	1.7 (0.9)	3.2 (1.5)	0.3024	2.9 (1.5)	2.1 (0.9)	0.2117	2.7 (1.3)	2.2 (1.3)	0.6072

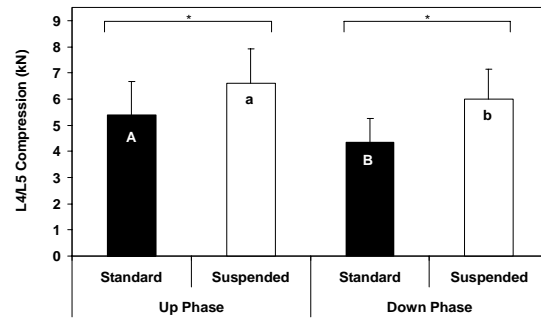


Figure 2: Comparison of L4/L5 compression forces estimated during STAN and SUS. Mean values are presented; error bars represent standard error of the mean. Bars labeled with different letters are significantly different from one another.

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