TRUNK AND SHOULDER MUSCLE ACTIVITIES DURING PUSH-UP EXERCISE ON STABLE AND UNSTBLE SURFACES

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The purpose of this study was to evaluate muscle activity of the prime movers and core stabilizers on stable and unstable surfaces during push-up exercise. Subject: Fourteen healthy male participants (age, 21.6 ±2.3 years; height, 174.7 ±8.1cm; weight, 68.2 ±16.4kg) without low back pain and shoulder injury in the past year were recruited. The participants completed push-up exercise in three conditions: on the ground, air disc and sling. EMG activities of external abdominal oblique, pectoralis major, and anterior deltoid muscles and elbow joint kinematics were recorded. Our results showed that external abdominal oblique muscle had significantly greater activity in the sling group (p <.05). Unstable resistance exercises with sling can be instituted during training to induce the external abdominal oblique activation and to improve core stability.

KEY WORDS: sling exercise, core muscle, muscle activation.

INTRODUCTION: In the past decade, there has been a shift toward functional training and away from the traditional weight training approach (Akuthota, Ferreiro, Moore, & Fredericson, 2008). Functional training done through natural movements and on multiple planes may lead to better coordination among multiple muscles and joint stability (Hodges & Richardson, 1996; Norwood, Anderson, Gaetz, & Twist, 2007). One tenet of functional training is core training, which has grown considerably popular throughout the health and fitness industry in recent years (Willardson, 2007). Realizing that muscles do not operate in isolation during sport and everyday activities, exercise regimens have been designed to integrate training of the core muscles with training of the extremities (Marshall & Murphy, 2005). Many believe that the most effective way to execute this integrated training is to perform traditional exercise movements on unstable surfaces (Kibler, Press, & Sciascia, 2006; Paul & Bernadette, 2006), but scientific evidence has yet to conclusively substantiate this concept. Therefore, the purpose of this study was to evaluate muscle activity of the prime movers and core stabilizers on stable and unstable surfaces during the push-up exercise.

METHODS: Subject: Fourteen healthy male participants (age, 21.6 ±2.3 years; height, 174.7 ±8.1cm; weight, 68.2 ±16.4kg) without low back pain and shoulder injury in the past year. Measurements: Subjects were asked to perform 3 push-ups in each condition while muscle activates and elbow flexion angles were monitored simultaneously during push-up exercise. Bipolar surface EMG electrodes were placed on the skin above muscle belly of the anterior deltoid, pectoralis major, and external abdominal oblique muscles. All electrodes were placed on the right side of the body, skin surfaces for electrode placement were shaved, abraded, and cleansed with alcohol to improve the conductivity of the EMG signal The Zebris sensors will affixed to the middle of the forearm and middle of the humerus to monitor elbow angle.
Procedures: 1. Participants assume a same prone position on the ground/air disc/sling (Figure 1). 2. Keep the body in a straight line from head to toe. 3. Lower the torso to the ground until the elbows form a 90 degree angle. 4. Raise the body up until the arms back to the straight position.
Participants performed push-ups at a rate of 72 per minute with the use of metronome and completed the 3 conditions, ground, air disc and sling of push-ups, in random order.

Data analysis: The EMG signal was collected at 1,000 Hz and filtered (50–500 Hz), used by Zebris EMG Measuring System (Zebris Medical GmbH, Germany). The maximum amplitude of the root mean square (RMS) of the EMG signal was evaluated with the Spike2 software program (Cambridge Electronic Design, Cambridge, UK) and normalized using the values of MVICs. Statistical Analyses: One-way analysis of variance (ANOVAs) with repeated measures were used. The 1-way ANOVA compared RMS values of EMG between ground, air disc and sling conditions.. Differences were considered significant at a $p < 0.05$ level. LSD procedure was utilized for post-hoc analysis.

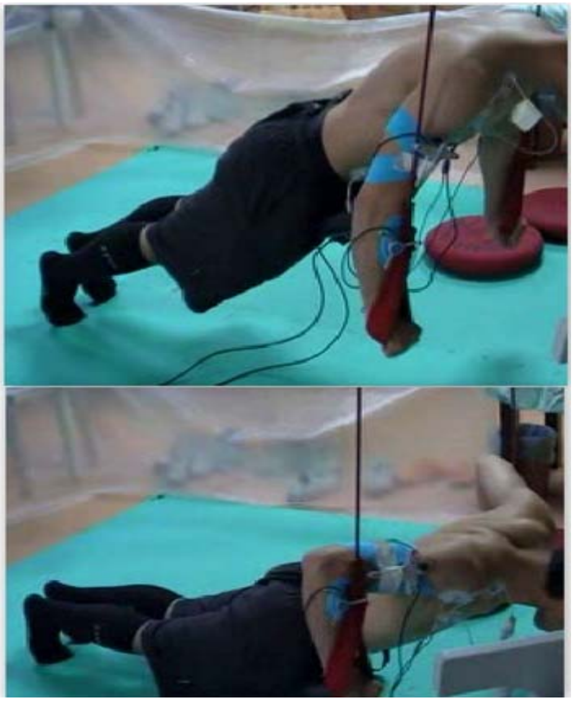

Figure 1: Sling exercise body position.

RESULTS: For the different surfaces (table 1), one-way ANOVA revealed that the main effect for condition was significant, with sling being 60.2% greater than air disc ($p < .05$); and air disc being 28.6% greater than ground ($p < .05$). External abdominal oblique muscle had significantly greater muscle activity in the sling group ($F(2, 39) = 4.31$, $p < .05$). But, muscle activities for anterior deltoid and pectoralis major did not show significant difference among the three conditions.

Table 1: Average normalized root mean square (RMS) electomyographic (EMG) results measured for the different surfaces.

	Ground (1)		Air disc (2)		Sling (3)			
	M	SD	M	SD	M	SD	F(2, 39)	Post hoc
External abdominal oblique	.84	.43	1.08	0.58	1.73	1.18	4.31*	3 > 2, 1
Pectoralis major	.77	.26	.74	.20	.82	.30	.34	
Anterior deltoid	.66	.21	.66	.11	.72	.18	.45	

* $p < .05$

DISCUSSION: We found that performing push-up exercise on the sling exercise system induced significantly higher muscle activation of the external abdominal oblique muscle. That is likely due to higher demands of trunk stability when performing push-up exercise during unstable condition, especially when using the sling system.

No significance was found in pectoralis major muscle and anterior deltoid muscle among the 3 exercise types. Although in the push up exercise the external abdominal oblique muscle is not the primary mover, but its activation is required to keep the trunk in a stabilized position, so that the primary movers, pectoralis major muscle and anterior deltoid muscles, can complete the push up task (Mori, 2004; Cresswell, Oddsson, & Thorstensson, 2006). The sling is more difficult than other unstable surfaces such as air disc, thus it requires greater muscle activation, and this is likely to be the reason that external abdominal oblique muscle has more activation in all 3 condition.

During push-ups, body weight shifts constantly to challenge the body's normal and stable orientation. This leads to constant adaptations of the support zones from weight shifts by the activation a number of control strategies including reflexive and reactive muscular responses. When exercising with the body frame horizontal to the support surface on the unstable platform device, the core muscle groups including external abdominal oblique are reflexively activated to hold the horizontal alignment of the unstable platform (Haynes, 2004). So we saw that core stabilizer muscle(external abdominal oblique) has more activation than the primary movers of shoulder joint (pectoralis major and anterior deltoid).

In addition, some of the studies have established that sling unstable training resulted in stronger and more stable lumbar-pelvic-hip complex and may contribute to higher rotational velocity in multisegmental movements. So training exercise with sling can improve not only maximal muscle strength but also sports performance (Prokopy, Ingersoll, Nordenschild, Katch, Gaesser, & Weltman, 2008; Saeterbakken, van den Tillaa, & Seiler, 2011; Huang, Chang, Chang, & Tew, 2009).

CONCLUSION: Unstable resistance exercises with sling can be instituted during training to induce greater activation of core mucles such as external abdominal oblique, which could promote better core stability.

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