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Electromyographic Comparison of a Stability Ball Crunch With a Traditional Crunch

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Abstract. Sternlicht, E., S. Rugg, L.L. Fujii, K.F. Fomomitsu, and M.M. Seki. Electromyographic comparison of a stability ball crunch with a traditional crunch. *J. Strength Cond. Res. 21(2): 506–509. 2007.*—The purpose of this study was to compare abdominal muscle activity while performing a crunch on a stability ball with a traditional crunch. Forty-one healthy adults (23 men and 18 women) participated in the study. The subjects performed the crunch with the ball in 2 positions, 1 with the ball at the level of the inferior angles of the scapula (SB-high) and 1 with the ball at the level of the lower lumbar region of the back (SB-low). Surface electromyography was recorded from the upper and lower portions of the rectus abdominis and the external oblique during each repetition. Electromyography values were analyzed using repeated measures analyses of variance and pair-wise comparisons. Muscle activity for the upper and lower portions of the rectus abdominis and external oblique for a traditional crunch was significantly lower than for the crunch performed in the SB-low position but significantly greater than the SB-high position. Our data also showed that, on average, the abdominal muscle activity doubled when the stability ball was moved from the upper to the lower back position. These results support previous findings that a stability ball is not only effective for training the abdominal musculature, but, with the correct placement, it can also significantly increase muscle activity when compared with a traditional crunch. In addition, our results suggest that ball placement is critical for matching the appropriate overload to the condition level of the user.

Key Words. unstable surface, exercise, muscle recruitment, rectus abdominis

Introduction

The stability ball has been used regularly in a rehabilitation setting and more recently gained popularity in the recreational and gym markets. For rehabilitation, the stability ball along with other unstable surfaces has been used mainly for proprioceptive adaptations. In gyms, athletic training facilities, and home video and exercise programs, the ball has been used not only for balance and proprioceptive adaptations but also for conditioning and toning. Along with its use to target and train the abdominal musculature, it is now widely used to train the whole body.

The stability ball is one of many portable abdominal exercise devices that have entered the fitness industry. To date, numerous studies have found most portable exercise devices to be similar in effectiveness or less effective at recruiting the abdominal musculature than a traditional crunch (2, 3, 5–7, 9, 10, 14–22). Of the 50 or more abdominal devices tested and reported in peer-reviewed scientific journal articles, only a few have been found to be more effective at recruiting the abdominal musculature than a traditional crunch (5, 8, 16, 17).

Numerous studies have looked at the effectiveness of an unstable surface at recruiting both the abdominal musculature (2, 6, 7, 10, 15, 18) and other muscle groups (1, 4, 12, 13, 15). Several studies have shown an increase in abdominal muscle activity when using a stability ball relative to performing a crunch on a stable surface (2, 6, 7, 18). In contrast, Hildenbrand and Noble (10), Lehman and colleagues (11), and Stanton and others (15) reported no significant difference in abdominal muscle electromyography (EMG) activity while performing a crunch on either a ball or a stable surface.

The purpose of the following study was twofold: (a) to compare the abdominal muscle activity while performing a crunch on a stability ball with the ball at the level of the inferior angles of the scapulas and with the ball at the level of the lower lumbar region of the back and (b) to compare the muscle activity recorded when using the stability ball in each position to a traditional crunch.

Methods

Experimental Approach to the Problem

In this study we wanted to determine the effect of ball placement on the recruitment of the abdominal musculature when performing a crunch motion and to determine how the activity compared to when performing a traditional crunch. Mean EMG recordings from the upper and lower portions of the rectus abdominis and external oblique from 41 subjects provided the data needed to evaluate the effectiveness of each movement. All subjects performed a full crunch (head, neck, and shoulder blades raised from the floor) and were then instructed to duplicate that range of motion as closely as possible while on a ball placed either at the level between the inferior angles of each scapulas (SB-high) or at the level of the lumbar region of their back (SB-low). To ensure valid comparisons in our EMG data, velocity of movement was also controlled across movements and subjects. Over the years of testing numerous abdominal devices, we have found that our male and female subjects produced similar abdominal muscle activity patterns across devices. For that reason we did not separate the data by gender.

Subjects

Forty-one healthy adult volunteers (23 men and 18 women) participated in this study. The subjects' mean (± *SD*) for age, height, and body mass were 20.3 (± 1.5) years, 177.5 (± 8.9) cm, and 74.0 (± 14.7) kg, respectively. Subjects were instructed on how to perform each exercise properly prior to collecting data. After receiving an explanation of the experimental protocol, each subject practiced the proper technique for each exercise and signed a university-approved informed consent form. All subjects were free of acute or chronic low back pain or injury prior to the study. Subject selection was limited to individuals with sufficiently low subcutaneous adipose tissue to permit accurate measurement of muscle activity.

Table 1. Mean electromyographic values (mean ± *SD*) for the three movements tested ($N = 41$).

Device	Muscle (volts)		
	Upper rectus abdominis	Lower rectus abdominis	External oblique
Stability ball (low)	**1.66 ± 0.99**	**0.77 ± 0.50**	**0.57 ± 0.30**
Stability ball (high)	1.00 ± 0.68*†	0.40 ± 0.27*†	0.28 ± 0.12*†
Crunch	1.27 ± 0.78	0.56 ± 0.32	0.46 ± 0.32

* Significant decrease in muscle activity relative to a traditional crunch.

† Significant decrease in muscle activity relative to when the crunch is performed with the stability ball placed below the lower lumbar region of the back. **Bold** indicates significant increase in muscle activity relative to a traditional crunch. All values were significant at $p < 0.001$.

Table 2. Percent difference of mean electromyographic values relative to a traditional crunch ($N = 41$).*

Device	Muscle (volts)		
	Upper rectus abdominis (URA)	Lower rectus abdominis (LRA)	External oblique (EO)
Stability ball (low)	131	138	124
Stability ball (high)	79	71	61
Crunch	100	100	100

* Because the crunch is the standard to which the other exercises were compared, the EMG values for the URA, LRA, and EO during the crunch were assigned a value of 100%.

Experimental Design

After appropriate instruction on the proper technique for each variation on the ball and for executing a proper crunch, subjects performed 1 set, 8–10 repetitions per set, for each abdominal exercise. Because most abdominal exercises and portable devices mimic the mechanics of performing a crunch and not a sit-up, this study used the traditional crunch as the criterion measure. Condition testing order was randomized across subjects, and all data for each subject were collected during a single session. All subjects performed a full crunch (head, neck, and shoulder blades raised from the floor) and were then instructed to duplicate that range of motion as closely as possible with movement performed on the ball

To ensure temporal consistency, each subject was instructed to perform each set at a constant speed during the concentric and eccentric phase. A metronome was used to pace each phase of the movement at a rate of 1.5 seconds per phase (concentric and eccentric). Sufficient rest, of more than 2 minutes, was allowed between trials to avoid fatigue. None of the subjects commented that they felt fatigued at any point during the data collection session. The EMG activity was assessed for 5 consecutive crunches in each set. The criterion measure was the mean EMG value for each set.

In the traditional crunch, hips and knees were flexed to approximately 45° and 90°, respectively, with the hands at the side of the subject's head. Each subject was instructed to flex his or her trunk so their head and shoulders, and therefore scapulas, would clear the mat. The same range of motion instructions were used while performing the crunch on the ball. A ball size of 70 cm was used for all subjects and accommodated the variation in subject height. The ball was measured periodically to ensure it remained that size for all subjects.

Electromyographic Recording

Muscle activity was measured using a standard noninvasive EMG system (BIOPAC Systems, Inc, Goleta, CA). Electromyographic recordings were collected using silver-silver chloride bipolar surface electrodes (EL208S; BIOPAC) placed on the skin overlying the right upper portion of the rectus abdominis (URA), the right lower portion of the rectus abdominis (LRA), and the right external oblique (EO). An unshielded ground electrode (EL208; BIOPAC) was placed on the skin overlying the acromion process. The electrodes were oriented parallel to the muscle fibers with an interelectrode distance of approximately 1.5 cm. Prior to electrode application, the skin over each electrode was shaved and cleansed with alcohol to reduce the impedance at the skin electrode interface. Electromyographic signals were sampled at 1,000 Hz per channel and amplified (gain of 5,000) and band-pass filtered (10–400 Hz) using BIOPAC Systems amplifiers. Signals were then passed through a BIOPAC Systems Model MP150 connected to an IBM i1200 laptop computer for analysis.

Statistical Analyses

Statistical analyses of EMG values were performed using SPSS Version 11.5.1 (SPSS, Inc, Chicago, IL). First, the intraclass correlation coefficient for each muscle group was calculated as an index of measurement reliability. Second, overall differences among the 3 movements, effect size, and observed power were examined with a repeated measures analysis of variance on data for each muscle group; the Greenhouse-Geisser correction was used, as is recommended for repeated measures with more than 2 levels (23). Differences between means were deemed statistically significant when $p \leq 0.05$.

Results

Mean EMG data showed that for each exercise tested, the upper and lower portions of the rectus abdominis and the external oblique were recruited (Table 1). Because the crunch is the standard to which the other exercises were compared, the EMG values for the URA, LRA, and EO during the crunch were assigned a value of 100% and the activities of each muscle group for the exercises tested were expressed relative to the crunch (Table 2 and Figure 1).

A crunch performed with the stability ball placed at the level of the lower lumbar region of the back exhibited significantly greater URA, LRA, and EO activity by 31%, 38%, and 24%, respectively, than a traditional crunch (Table 2). In contrast, the crunch performed with the stability ball placed below the scapulas elicited significantly less URA, LRA, and EO activity by 21%, 29%, and 39%, respectively, than a traditional crunch (Table 2).

In addition, a crunch performed with the stability ball placed at the level of the lower lumbar region of the back elicited significantly greater URA, LRA, and EO activity by 66%, 93%, and 104%, respectively, than when the

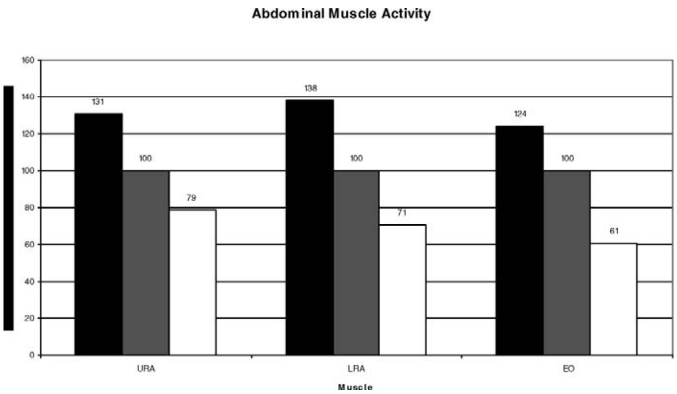

FIGURE 1. Percent difference of mean electromyographic values for the upper portion of the rectus abdominis (URA), lower portion of the rectus abdominis (LRA), and external oblique (EO) relative to a traditional crunch. The solid bars represent the data for the crunch performed on the stability ball placed on the lower lumbar region of the back, the grey bars represent the data for the traditional crunch, and the white shaded bars represent the data for the crunch performed on the stability ball placed below the inferior angle of the scapula.

crunch was performed with the stability ball placed below the scapulas (Table 2).

DISCUSSION

An important finding of the present study is that the position of the ball while performing a crunch is a major factor in determining the degree of abdominal muscle activity and may help explain the previous results reported in the literature. This study supports previous research that found a significant increase in abdominal muscle activity while performing a crunch on a stability ball compared with performing the same movement on the floor (2, 7, 18). In addition, the lack of a significant increase in muscle activity on the ball relative to the floor, as reported by Hildenbrand and Noble (10), may result from the second important finding of the present study, namely, that ball position is a major factor in determining the degree of abdominal muscle activity while performing a crunch.

When the ball was placed high on the back, at the level of the inferior border of the scapulas, our data showed a significant reduction in abdominal muscle activity when compared with either the lower ball position or a traditional crunch. A lower ball placement not only requires a greater proportion of the trunk to be lifted during the crunch motion but also requires greater trunk stabilization in the horizontal position because there is no support for the upper trunk from either the floor or the ball. As expected, therefore, more abdominal muscle activity would be needed when performing the crunch motion using the lower ball placement than when performing either the higher ball placement or a traditional crunch. Based on our findings, abdominal muscle activity increased by 66%, 93%, and 104% for the URA, LRA, and EO, respectively, when the ball was placed below the lower lumbar region of the back relative to when the ball was placed below the inferior angle of the scapulas. In comparison, the lumbar ball placement elicited lower, but still significant, increases in abdominal muscle activity of 31%, 38%, and 24% for the URA, LRA, and EO, respectively, when compared with the traditional crunch.

Although the focus of this study was to look at differences in abdominal muscle activity while performing a crunch movement, other groups have looked at training adaptations when exercising on stable vs. unstable surfaces. Cosio-Lima and others (7) found significantly greater mean EMG activity using a stability ball, compared with a stable floor surface, after 5 weeks of training. No significant differences were found, however, for either the subject's heart rate response or strength measures in their study. Stanton and colleagues (15) found a significant increase in core stability with no change in measures related to performance, including $\dot{V}O_2max$, running posture, and running economy. Although several studies have found significant increases in muscle EMG activity using a stability ball, its use by athletes to improve athletic performance remains questionable (15, 21).

In addition, it was not the purpose of this study to determine how best to perform a crunch motion to maximize its effectiveness but rather, given similar speed and range of motion across crunch movements, to determine how modifying ball position with respect to the spine effects muscle activity while performing a crunch motion. The results of this study show that of the 2 ball placements analyzed, only the lower lumbar position elicited significantly greater abdominal muscle activity than a traditional crunch. It is also true that the traditional crunch elicited significantly greater abdominal activity than the crunch performed with the stability ball placed under the inferior angle of the scapulas. The generalization, therefore, that a stability ball crunch is more effective than a traditional crunch is only true if the correct ball position is used.

PRACTICAL APPLICATIONS

A benefit to the therapist or trainer of the present findings is the ability to vary the activity required by the abdominal muscles simply by changing their client's position on the ball before performing the crunch movement. For those with abdominal muscle weakness, a high ball placement will allow them to perform the crunch motion with less effort than when performed on a stable bench or floor. In addition, as their condition and fitness improve, the ball can progressively be positioned lower on their back to increase the training load and, therefore, increase their abdominal muscle activity.

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