



## Electromyographic Activity of Rectus Abdominis during a Suspension Push-Up Compared to Traditional Exercises

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### ABSTRACT

**Snarr RL, Esco MR, Witte EV, Jenkins CT, Brannan RM.** Electromyographic Activity of Rectus Abdominis During a Suspension Push-up Compared to Traditional Exercises. **JEPonline** 2013;16(3):1-8. The purpose of this study was to compare the electromyographic (EMG) activity of the rectus abdominis (RA) across three different exercises [i.e., suspension pushup (SPU), standard pushup (PU) and abdominal supine crunch (C)]. Fifteen apparently healthy men ( $n = 12$ , age =  $25.75 \pm 3.91$  yrs) and women ( $n = 3$ , age =  $22.33 \pm 1.15$ ) volunteered to participate in this study. The subjects performed four repetitions of SPU, PU, and C. The order of the exercises was randomized. Mean peak EMG activity of the RA was recorded across the 4 repetitions of each exercise. Raw (mV) and normalized (%MVC) values were analyzed. The results of this study showed that SPU and C elicited a significantly greater ( $P < 0.05$ ) activation of the RA reported as raw ( $2.2063 \pm 1.00198$  mV and  $1.9796 \pm 1.36190$  mV, respectively) and normalized values ( $68.0 \pm 16.5\%$  and  $52 \pm 28.7\%$ , respectively) compared to PU (i.e.,  $0.8448 \pm 0.76548$  mV and  $21 \pm 16.6\%$ ). The SPU and C were not significantly different ( $P > 0.05$ ). This investigation indicated that SPU and C provided similar activation levels of the RA that were significantly greater than PU.

**Key Words:** Suspension Training, EMG, Exercise, Core

## INTRODUCTION

Previous trends in strength and conditioning have primarily focused on exercises designed for sport-specificity (kicking, jumping, throwing, and pushing) and not specific core training (9). However, the recent sport scientific literature indicates that strengthening the core musculature leads to a greater transfer of power to the limbs during functional movements, which appears to improved sports performance (1,13,16,19). During athletic performance, it takes the entire body working as one functional reactive unit to provide speed, velocity, agility, and strength (19). In addition, the increase in core strength may also prevent injuries, improve coordination, and help to ensure proper spine protection and function (4,12,18,20,23). Therefore, from a functional and health point of view, further investigation on exercises designed to target the core musculature is warranted.

The traditional push-up (PU) is one of the most well-known exercises to target the musculature of the upper body (e.g., pectoralis major, triceps brachii, and anterior deltoid). Often, it is used as a test to measure upper body muscular endurance (11). Interestingly, several studies have shown that the traditional push-up also provides an isometric challenge to abdominal wall musculature (2,12), which becomes activated to a greater extent with the introduction of a suspension device (8). However, most investigations have focused on established modalities designed to challenge core stability, such as the Swiss Ball or BOSU. There is very little research to date that investigates the effects of a push-up using a suspension device (SPU) on electromyographic (EMG) activity of core musculature.

Of the limited data in this area, Beach et al. (2) compared EMG activity of the rectus abdominis (RA) between PU and SPU. The results indicated that the RA was elicited to a significantly greater extent during the SPU compared to PU. However, additional research is needed to determine if SPU activates the RA to the level of traditional abdominal exercises. The purpose of this study was to compare the EMG response of the RA during three exercises: SPU, PU, and traditional supine crunch (C). For comparative purposes, C was used in this investigation as it is the current standard to which most exercises are compared when investigating RA activity (12,18,22). It was hypothesized that the SPU would elicit a greater activation of the RA compared to PU and C.

## METHODS

### Subjects

Fifteen apparently healthy men ( $n = 12$ ) and women ( $n = 3$ ) volunteered to participate in this study. Descriptive statistics are shown in Table 1. All subjects were asked to complete a health history questionnaire and informed consent. Those who were free from musculoskeletal dysfunctions, cardiovascular, and metabolic diseases were allowed to participate. The study was approved by the Institutional Review Board at Auburn University at Montgomery.

**Table 1. Descriptive Data of the Subjects (\* $P < 0.05$ ).**

Conditions	Males	Females	All
Age (yrs)	25.75 $\pm$ 3.91	22.33 $\pm$ 1.15	25.27 $\pm$ 3.86
Height (cm)	179.08 $\pm$ 7.74	172.67 $\pm$ 6.43	177.8 $\pm$ 7.75
Weight (kg)	81.17 $\pm$ 7.28	66.33 $\pm$ 8.33*	78.2 $\pm$ 9.45
BMI	25.35 $\pm$ 2.33	22.23 $\pm$ 2.38*	24.73 $\pm$ 2.59

## Procedures

### **Surface Electromyography**

Electromyographic activity was recorded using a MP150 BioNomadix Wireless Physiology Monitoring system (Biopac System, Inc., Goleta, CA). Two Ag-AgCl surface electrodes (Biopac EL504, Biopac Inc. Goleta, CA) were placed 2 cm to the right of the umbilicus and 3 cm apart (vertically) directly over the muscle fibers. A ground surface electrode was placed directly over the right anterior superior iliac spine. Prior to all electrode placements the skin sites were properly prepared by shaving (if needed), exfoliating, and cleansing with alcohol wipes to reduce any impedance. The EMG signals were sampled at a rate of 1.000 kHz using Acqknowledge 4.2 software (Biopac, Inc., Goleta, CA). The EMG values were stored in a Dell PC for analysis.

### **Exercise Trials**

The subjects were instructed on proper exercise technique of the SPU, PU, and C. If the exercises were not completed with proper technique, the data were not used in the collection process. Before the exercise trials, a maximum voluntary contraction (MVC) of the RA was determined to allow normalizations of the EMG data (%MVC). To obtain these values, the subjects assumed a supine position on a padded mat with the knees flexed to 90° with the arms crossed over the chest. Then, the subjects attempted to perform a sit-up while the investigator provided a matched resistance to prevent motion. After the MVC data were recorded, the subjects performed the exercises.

**Suspension Push-Up (SPU):** A suspension device (TRX® Suspension Trainer®, Fitness Anywhere, LLC) was attached overhead to a standard smith machine. The handles of the suspension device were placed at the height of the fitness step (in which the subjects' feet were placed during the exercise) to ensure that the hands and feet were at the same level while performing the push-ups. The subjects then assumed a standard push-up position with their hands placed in the handles of the suspension device (starting position) that were slightly wider than shoulder-width apart. While maintaining a neutral spine position with the feet together, the subjects were instructed to perform a push-up. In order for successful trial to be recorded, the subjects' chest reached the level of the hands at the transitional portion of each repetition (i.e., between the concentric and eccentric phases).

**Standard Push-Up (PU):** All traditional push-ups were performed on a flat, stable surface with hands placed slightly wider than shoulder-width apart and fingers pointed forward. During the standard push-up, the subject was instructed to lower the upper body until the chest reached 2 inches from the floor. If the correct depth was not reached, the repetition was repeated.

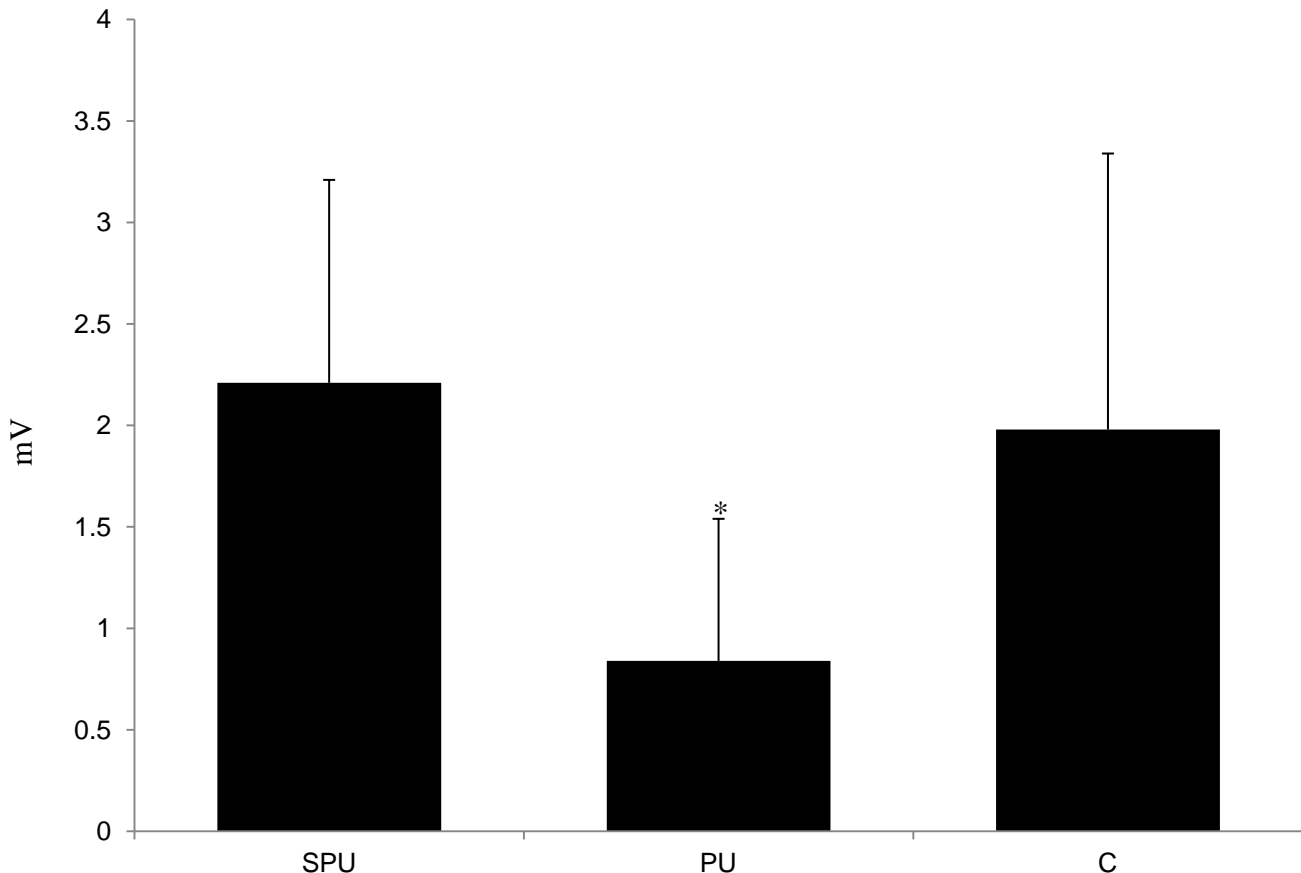
**Lying Supine Crunch (C):** To perform the crunch, the subjects were instructed to lay supine with knees flexed to 90°, feet flat on the floor, and arms crossed over the chest. The subjects then flexed the spine to lift the head and shoulders until the inferior angle of the scapula did not touch the mat. Then, the subjects returned to the starting position.

### **Statistical Analysis**

The data were analyzed using SPSS/PASW Statistics version 18.0 (Somers, NY). Repeated measures analysis of variance (ANOVA) was used to determine if there were differences in raw (mV) and normalized (%MVC) RA EMG values across the three exercises. Bonferroni follow-up tests were used to further examine the differences. A priori statistical significance was set to a value of  $P < 0.05$ .

## RESULTS

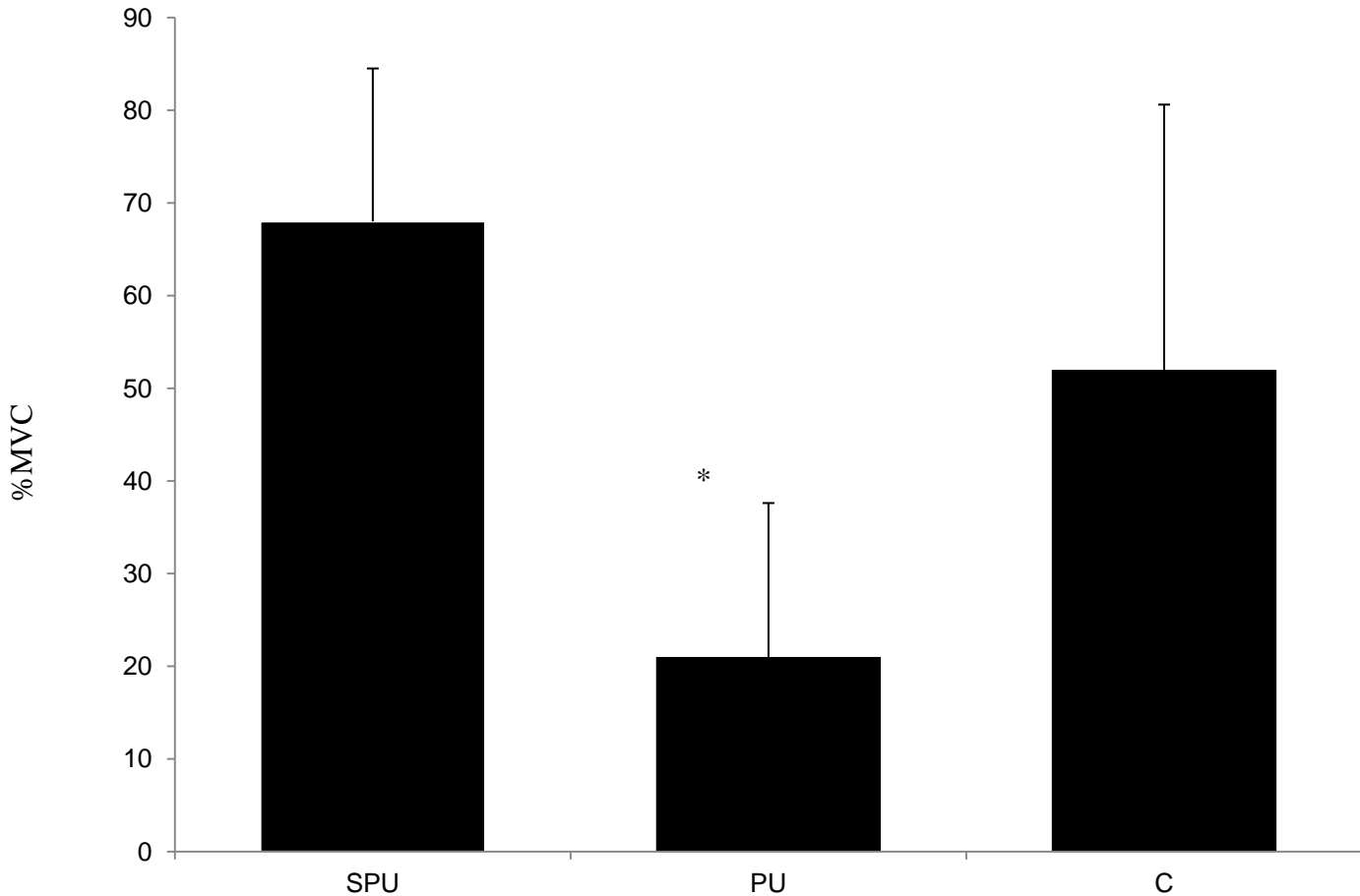
All of the subjects successfully completed each exercise trial. The RA activity during the SPU, PU, and C exercises were  $2.21 \pm 1.00$  mV,  $0.84 \pm 0.77$  mV, and  $1.98 \pm 1.36$  mV, respectively (Figure 1). When normalized for MVC, RA activity during SPU, PU, and C were  $68.0 \pm 16.5\%$ ,  $21 \pm 16.6\%$ , and  $52 \pm 28.7\%$ , respectively (Figure 2). The raw and %MVC values were lower during PU compared to SPU and C ( $P < 0.05$ ). The differences between SPU and C in raw and normalized RA values were not significant ( $P > 0.05$ ).



**Figure 1. Comparison of Electromyographic Activity (mV) of the Rectus Abdominis Across Three Exercise Trials: Suspended Push-Up (SPU); Traditional Push-Up (PU); and the Crunch (C). \*PU was significantly lower than SPU and C ( $P < 0.05$ ).**

## DISCUSSION

The purpose of this study was to determine if the SPU elicited greater activation of the RA when compared to the PU and C. Our findings were consistent with a previous study by Beach et al. (2) in that the RA was activated to a significantly greater extent during the SPU when compared to PU. However, the most important finding of the current investigation extends previous reports by demonstrating a similar RA level of activation during SPU compared to a traditional abdominal exercise, the C.



**Figure 2. Comparison of Electromyographic Activity (%MVC) of the Rectus Abdominis Across Three Exercise Trials: Suspended Push-Up (SPU); Traditional Push-Up (PU); and the Crunch (C). \*PU was significantly lower than SPU and C ( $P < 0.05$ ).**

Exercise devices designed to challenge stability are relatively recent trends to increase core strength along with improving coordination, balance, and sports performance (21). These devices are typically used while performing abdominal-specific exercises, though conflicting evidence exists as to whether these unstable pieces of equipment have a significant effect on core stability. Several studies report an increased challenge to abdominal wall activation with the instability training devices (3,6,22). For example, Duncan (6) demonstrated that RA activity was greater when the C was performed on a Swiss Ball than on the floor. However, several other studies demonstrated opposite findings (18,21), with some authors suggesting stability devices could actually assist the subject with performing the abdominal-specific movement (24).

Additional studies have shown that when closed kinetic chain lower body movements (e.g., squat and deadlift) are performed on unstable devices, RA activation decreases compared to the traditional approach (10,17,25). This is primarily because of a decreased force production and lower load displacement when the exercises were performed in the unstable environment. However, the suspension device increased RA activity of the push-up in the current study. Similar to our findings, Marshall and Murphy (15) demonstrated an increase in RA activation while push-ups were performed with the hands placed on a Swiss ball. Furthermore, Freeman et al. (8) demonstrated a 2.5-fold increase in RA activation when push-ups were performed with the each hand placed on a basketball.

Therefore, it seems reasonable to consider that when body-weight resisted movements of the upper extremities, such as the PU, are performed on unstable devices there is a greater muscular force production that leads to an increased RA activity.

Previous studies have also indicated that the plank or prone-bridge elicited higher values of RA activation when compared to traditional abdominal movements, such as the C (5,7). For example, Lehman et al. (14) demonstrated an increased RA activation when the prone-bridge was performed with the elbows placed on a Swiss ball. Therefore, because of the plank-like position and unstable nature of the upper body in the present study (i.e., hands in the suspension trainer), the SPU significantly increased RA activation.

## CONCLUSIONS

This study showed that the SPU provides a level of RA activation that is higher than the PU while comparable to the C. Thus, it is appropriate to conclude that the SPU can be used as a substitute for the C and vice versa. Individuals who are interested in developing a stronger core may benefit from new and unusual exercises, such as the SPU, (2,22) while also lowering their risk of injuries to the spine.

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