MUSCLE ACTIVATION OF DIFFERENT CORE EXERCISES

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ABSTRACT

Oliver, GD, Dwelly, PM, Sarantis, ND, Helmer, RA, and Bonacci, JA. Muscle activation of different core exercises. J Strength Cond Res 24(11): 3069–3074, 2010—Sport health care professionals are always trying to increase muscle activation while instructing exercises that are functional to the sport performance. However, the traditional core exercises are the ones typically performed. This study examined the muscle activation of the lumbopelvic hip complex during traditional core stability exercises and that of the sports performance movements using the CORE X. Fourteen healthy, college-age men (mean age 20.8 ± 3.9 years; mean height, 177.8 ± 10.9 cm; mean weight, 67.3 ± 9.9 kg) participated. Electromyographic (EMG) data were collected on the following muscles: dominant gluteus maximus, dominant gluteus medius, rectus abdominis (bilateral), external oblique (bilateral), and multifidis (bilateral). Results revealed a significant difference between the 2 different exercise programs for all muscles investigated except the external obliques (p < 0.05). The movements using the CORE X showed increased mean muscle activation for the dominant (57.8% maximum voluntary isometric contraction [MVIC]) and nondominant multifidus (56.4% MVIC) and the dominant gluteus maximus (48.3% MVIC) and medius (65.3% MVIC), whereas the traditional core exercises showed greater mean muscle activation for the dominant (45.1% MVIC) and nondominant rectus abdominis (47.4% MVIC) and external oblique (45.8% MVIC and 47.8% MVIC). The investigators were able to determine that while performing movements that mimicked more sports-related activities with the CORE X, there is a greater activation of the core musculature. Coaches, trainers, and athletic trainers should focus on training a core neutral while performing sports-specific movements that can be done with the CORE X.

KEY WORDS EMG, core strengthening, functional core exercises

INTRODUCTION

The core is composed of many more muscles than just the abdominals. The core has been recently described as the lumbopelvic hip complex (21). It is the lumbopelvic hip complex, or the core as commonly referred, that is the integral link in the functional ability of the kinetic chain (15). It has become a common practice to train the core, properly known as the lumbopelvic hip complex, in attempt to increase performance and improve lower extremity biomechanics (19). Within this lumbopelvic hip complex, there are more than 29 pairs of muscles working to stabilize the spine, pelvis, and hips during functional movements (1). Specifically, the core is composed of the anterior rectus abdominis and transverse abdominis; posterior erector spinae, multifidus, gluteus maximus, and hamstrings; lateral gluteus medius, gluteus minimus, and quadrates lumborum; and medial adductor magnus, longus, brevis, and pectineus (2). In addition, the base of the lumbopelvic hip complex is made up of the pelvic floor with the superior aspect consisting of the diaphragm. With efficient functionality of the entire lumbopelvic hip complex, one can maintain a strong, stable, and functional base for all movements (15,16). Kibler (15) has described that efficient core stability as the ability to control the movement of the trunk over the torso in attempt to transfer energy for integrated athletic activities.

The core is considered the integral link in the kinetic chain (15,16,21). All sporting movements incorporate the transfer of energy from one segment to the next in the kinetic chain model (15). Despite the skill being performed, it is paramount that athletes have the correct postural control when performing movement skills. If an athlete lacks in postural control, then they cannot transfer the optimal energy to the distal segments and ultimately will be susceptible to injury because of compensations that are made in attempt to make up for the lack of force production.
Lumbopelvic hip complex or core weakness and instabilities have been linked to injuries of both the upper and lower extremities (3–6,9,10,13,16,17). The lumbopelvic hip complex works to control anterior pelvic tilt, which results in femoral internal rotation and adduction that is a major cause of patellar femoral pain (13). Others have found that athletes who sustained injury over the course of a season displayed significant weakness in hip abduction and external rotation (16), all of which are major functions of the lumbopelvic hip complex.

Goals of strength and conditioning, or rehabilitation, are for the athlete to achieve peak performance. In attempts to achieve optimal peak performance, one has to functionally train athletes for competition. Essentially, the musculature involved needs to be strengthened and conditioned functionally throughout the movements associated with the athlete's sport. For the athlete to perform these sport-related functional movements, they have to be able to support their own body weight through postural control. Sports performance functionality is the key to a strong strength and conditioning and rehabilitation program; however, this concept is often dismissed when it comes to strengthening core musculature. Typically, when strength and conditioning programs train to strengthen the core musculature, they often focus on the traditional abdominal exercises. Traditional core strengthening exercises such as the plank, crunch, and leg lifts are done with success; however, how do their movements transfer to sport performance movements?

Previously, studies have compared commercial core strengthening devices, and they have demonstrated effective activation of the core musculature (8,11,18,20). However, these exercises lack in their ability to allow for sports performance types of movements while activating the core. Typically, athletes are trained the athletic or ready position (head up, back straight, hip and knees flexed) in which they are to maintain so that any sport movement can be initiated quickly. It is from the functional ready position that they are able to quickly initiate movement changes. If athletes depend on their core musculature as the base of support for the entire link system, clinicians need to address the motor control of the core in the positions that their athletes are functioning, and the positions where they could be prone to injury. In attempts to train the core adequately for optimal neuromuscular control, clinicians need to address training in a more functional athletic ready position. Therefore, the purpose of our study was to compare muscle activation of the core during traditional core stability exercises to that of exercise movements done with the CORE X. The CORE X is a device that consists of elastic bands and Velcro closures that make an X across the core. The Velcro attaches the right arm to the left leg and the left arm to the right leg (see Figure 1). It was our hypothesis that the exercise movements performed with the CORE X would have greater core muscle activation as compared to the traditional core exercises.

**Methods**

**Experimental Approach to the Problem**

The goal of the experiment was to determine if the exercise movements using the CORE X would provide greater core muscle activation than traditional core exercises. The effectiveness of the 2 exercises was analyzed by examining the normalized surface electromyographic (sEMG) data using a multivariate analysis of variance (MANOVA). In particular, the percent of maximum voluntary isometric contractions (MVICs) for each muscle was examined and compared across the 2 types of core exercises.

**Subjects**

Fourteen healthy, college-age men (mean age 20.8 ± 3.9 years; mean height, 177.8 ± 10.9 cm; and mean weight, 67.3 ± 9.9 kg) participated in the study. The participants all had been involved in resistance training 3 times per week for the past 9 months and were considered physically active at the time of data collection. Physically active was defined as participating in cardiovascular physical activity for a minimum of 30 minutes, 3 days of the week. Participants had all been trained on the appropriate techniques used in the study. Before participation, participants were informed of possible risks and signed a consent form approved by the University of Arkansas Institutional Review Board.
Instrumentation

The CORE X (CORE X System, corexsystem.com) is constructed of 2 elastic bands with Velcro (Velcro USA Inc., Manchester, NH, USA) that wraps around the participant’s wrists and thighs. One band attaches the left thigh to the right wrist, and the other band attaches from the right thigh to the left wrist. Per manufacturer’s instructions, the bands on the thigh attach approximately 5 in. proximal to the knee, with the wrist straps secured at the wrist. The cords should be on tension or taut when the individual is in an athletic position of slight knee flexion, hip flexion and then upper arms at side with elbows flexed to 90°. The CORE X system describes numerous exercises and movements, but for the purpose of this study, we chose 4 exercise movements that mimicked typical basic sport performance: the drop step, cross step, core fire, and core rotation. The 4 movements were chosen because they are the functional base movements for the CORE X.

Electromyographic data were collected using 3M (3M, St. Paul, MN, USA) Red-Dot bipolar surface electrodes that were placed over 8 muscle bellies according to method of Basmajian and Deluca with an interelectrode distance of 25 mm (2,12). The muscles targeted were the following: dominant gluteus maximus, dominant gluteus medius, rectus abdominis (bilateral), external oblique (bilateral), and multifidus (bilateral). Surface electrodes were chosen because they were noninvasive and were able to reliably detect surface muscle activity.

Before electrode placement, the investigators shaved, abraded and cleaned the participant’s skin with alcohol. Adhesive 3M Red-Dot electrodes were placed over the participant’s muscle bellies and parallel to the direction of the underlying muscle fibers. To assure proper electrode placement, an investigator (who was a certified athletic trainer and had previous training in sEMG) performed manual muscle tests through maximum isometric voluntary contractions (MVIC) based on the work of Kendall et al. (14). Three manual muscle tests were performed, to provide a value of each muscle’s MVIC, for a total of 5 seconds for each muscle group. The first and last seconds of each MVIC trial were removed from the data in attempt to obtain steady state results for each of the muscle groups. The manual muscle testing provided base line MVIC readings for which all sEMG data were based. All sEMG data were presented as a percent of the muscle’s MVIC.

Procedures

After electrode placement, investigators instructed the participants on the proper technique for the 4 moves with

**Figure 2. Cross Step**: Similar to the drop step, except the cross step was in a forward direction. All participants started in an athletic position with hip and knees flexed. As their right leg crossed in front of their body, their left shoulder flexed and elbow extended with arm crossing their body while their right shoulder and elbow extended.

**Figure 3. Cross Fire**: A combination of the drop step and cross step where the participants jumped and rotated at the pelvis 45° while feet remained shoulders distance apart, while the upper extremity rotates in opposite direction.
the CORE X, and the 4 traditional core exercises. Participants were randomly assigned in which order the exercises would be completed. Each participant performed several warm-up trials with verbal feedback on proper technique before trial recording. During the trials, participants were instructed on proper posture through verbal cues.

The traditional exercises performed were as follows:

**Plank.** Participants performed the plank on the toes and elbows with the spine and pelvis in neutral alignment and held for 5 seconds with 30-second rest between repetitions; participants performed 3 repetitions.

**Side Plank.** Participants performed the side plank on the forearm and with the top foot placed anterior to the bottom foot with the spine and pelvis in a neutral alignment and held for 5 seconds with 30-second rest between repetitions; participants performed 3 repetitions.

**Traditional Crunch.** Participants performed the crunch with the hips and knees flexed to approximately 90° with their hands near their ears. Investigators instructed each participant to flex his trunk, so the head and scapula were off the mat. Participants performed 3 repetitions at a metronome rate of 1.5 seconds per phase.

**Oblique Crunch.** Participants started the oblique crunch in the same position as the crunch. Participants were instructed to flex his trunk, so one scapula and the head were raised off the mat. Participants performed 3 repetitions at a metronome rate of 1.5 seconds per phase.

The CORE X exercises performed are illustrated and described in Figures 1–4.

**Electromyographic Analysis**

A Myopac Jr 10-channel amplifier (RUN Technologies Scientific Systems, Laguna Hills, CA, USA) with a common mode rejection ratio equal to 90 dB and set at a gain of 2,000 transmitted the sEMG raw data to The MotionMonitor™ motion capture system (Innovative Sports Training Inc, Chicago IL, USA). The sEMG data were sampled at 1,000 Hz. Filtering of all sEMG was employed using standard band-pass filtering set at cutoffs of 20 and 350 Hz, respectively. In addition, all sEMG data were notch filtered at 59.5 and 60.5 Hz.

Participants’ sEMG enveloped data were assessed, and mean maximum sEMG reference values for each muscle within the phase were calculated. Three trials of sEMG data were analyzed for each participant to determine average peak amplitudes for all muscles during each concentric and eccentric phase of the exercise.

**Statistical Analyses**

Data from each muscle were normalized by being expressed as a percent contribution of the MVIC to the total electrical activity.
activity of all muscles tested. Statistical analyses were performed by using SPSS 15.0 (Chicago, IL, USA). A MANOVA was conducted to evaluate the differences between the exercises performed with the CORE X and the traditional core exercises for the dominant gluteus maximus, dominant gluteus medius, rectus abdominis (bilateral), external oblique (bilateral), and multifidis (bilateral). Alpha was set a priori = 0.05. Effect size and statistical power were calculated using SPSS.

RESULTS

The MANOVA revealed each muscle exhibited greater activation during the exercise movements performed with the CORE X compared to the traditional core exercises (p < 0.001), except for the dominant and nondominant external obliques (p > 0.05) as illustrated in Figure 5. We calculated medium (7) effect sizes (d = 0.4–0.7 in Table 1), suggesting the results had clinical significance indicating the exercises with the CORE X system actually produced a greater activation of muscle potentials in the dominant gluteus maximus, dominant gluteus medius, rectus abdominis (bilateral), and multifidis (bilateral) than the traditional core exercises that were performed.

DISCUSSION

It was hypothesized that performing sport performance movements with the CORE X would have greater muscle activation of the core than traditional core exercises. The exercises using the CORE X activated the multifidi, gluteus maximus, and gluteus medius greater than the traditional exercises. The traditional core exercises, however, activated the rectus abdominis greater than the exercises using the CORE X. The external obliques were activated similarly between the 2 exercise programs. The greatest effect was observed in the dominant gluteus maximus, where the exercises using the CORE X system activated the gluteus maximus 52% MVIC and the traditional core exercises only averaged a 12% MVIC.

Traditionally, conditioning programs will target or train the anterior musculature of the core; the rectus abdominis through standard crunches and planks. However, with the core encompassing the entire lumbopelvic hip complex, which includes the anterior, posterior, medial, and lateral aspects of the core, training should address all components. If the core is not efficiently strong, then an athlete is susceptible to injury because of the weak kinetic chain (15,16,21).

Within the core musculature, the transverse abdominis is going to fire first with the multifidi following closely (21) with any type of movement that positions the extremities. Because of the nature of our study, only sEMG was used, and thus, we were not able to assess the muscle activation of the transverse abdominis; however, we were able to assess the multifidi. In addition to the multifidi, the gluteus maximus is paramount in stabilizing the pelvis. Lack of pelvic stability during any type of single limb support, ultimately predisposes an athlete to injury (21).

Table 1. F-value, significance, effect size, and power statistics for the dominant (d.) gluteus maximus, dominant gluteus medius, bilateral (dominant and nondominant [nd.]) rectus abdominis, bilateral external obliques, and multifidis between CORE X and traditional exercises.

<table>
<thead>
<tr>
<th>Muscle</th>
<th>df</th>
<th>F</th>
<th>Sig</th>
<th>Effect size</th>
<th>Power</th>
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<tbody>
<tr>
<td>d. multifidus</td>
<td>1</td>
<td>20.36</td>
<td>&lt;0.001</td>
<td>0.44</td>
<td>n/a</td>
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<tr>
<td>nd. multifidus</td>
<td>1</td>
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<td>&lt;0.001</td>
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<tr>
<td>gluteus maximus</td>
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<tr>
<td>gluteus medius</td>
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<td>&lt;0.001</td>
<td>0.47</td>
<td>n/a</td>
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<tr>
<td>d. rectus abdominis</td>
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<td>&lt;0.001</td>
<td>0.54</td>
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<tr>
<td>nd. rectus</td>
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<td>48.20</td>
<td>&lt;0.001</td>
<td>0.65</td>
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<tr>
<td>abdominis</td>
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</tr>
<tr>
<td>d. external oblique</td>
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<td>0.52</td>
<td>0.487</td>
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<tr>
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<td>0.67</td>
<td>0.241</td>
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df = degrees of freedom; d = dominant; nd = nondominant; sig = significance; n/a = not applicable.
Muscle Activation and Core Exercises

The investigators were able to determine that while performing sports performance types of movements from an athletic or ready position with the CORE X, a majority of the core musculature had greater activation than when performing traditional core exercises. Being able to condition the core while performing sporting movement through the use of the CORE X allows the CORE X system to be a great asset to core training regimens. With a stable and strong core, the athlete’s kinetic flow of energy is maximized and transmitted to the extremities. However, future investigations should observe the similarities between the functional training systems, similar to CORE X and actual athletic practice drills.

For dominant and nondominant external obliques, our statistical power (1 – β) as illustrated in Table 1 suggested that there may not have been a large enough sample size to determine no significance between the variables. Therefore, if the sample size were larger in an attempt to increase our statistical power, we may have observed greater differences between exercises using the CORE X system and traditional exercises in the external obliques. It is also believed that with more familiarity training using the CORE X system, participants would have activated the external obliques at a greater intensity than during traditional core exercises. Most people are familiar with the traditional core exercises, and therefore are likely to perform with better mechanics than something recently taught.

**PRACTICAL APPLICATIONS**

When training in the athletic or ready position with the CORE X, athletes are in a functional athletic position for almost every sporting endeavor. It is essential that athletes initiate sports movements with core or postural control in attempts to not only have effective energy transfer through the kinetic chain but also as an attempt to prevent injury. From this study, we were able to determine that performing exercises with the CORE X system allows for not only greater muscle activation, but the ability to perform movements from an athletic stance while training core and postural control. Therefore, sport-specific training and conditioning, should focus on training and maintaining a core neutral while performing the movements from an athletic ready position. Coaches, strength trainers, or athletic trainers could incorporate the CORE X system within the daily training regimen and obtain core strengthening benefits.

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**REFERENCES**


