A STUDY OF PHYSICAL FITNESS AND EXERCISE WITH CORE MUSCLE TOWARDS PHYSICAL FITNESS

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ABSTRACT:

The aim of this study was to systematically review the current literature on the electromyographic (EMG) activity of six core muscles (the rectus abdominis, the internal and external oblique, the transversus abdominis, the lumbar multifidus, and the erector spinae) during core physical fitness exercises in healthy adults. A systematic review of the literature was conducted on the Cochrane, EBSCO, PubMed, Scopus, and Web of Science electronic databases for studies from January 2012 to March 2020. The Preferred Reporting Items for Systematic Reviews and Metaanalyses (PRISMA) guidelines were used. The inclusion criteria were as follows: a) the full text available in English; b) a cross-sectional or longitudinal (experimental or cohorts) study design; c) the reporting of electromyographic activity as a percentage of maximum voluntary contraction (% MVIC), millivolts or microvolts; d) an analysis of the rectus abdominis (RA), transversus abdominis (TA), lumbar multifidus (MUL), erector spinae (ES), and the internal (IO) or external oblique (EO); e) an analysis of physical fitness exercises for core training; and f) healthy adult participants. The main findings indicate that the greatest activity of the RA, EO, and ES muscles was found in freeweight exercises. The greatest IO activity was observed in core stability exercises, while traditional exercises showed the greatest MUL activation. However, a lack of research regarding TA activation during core physical fitness exercises was revealed, in addition to a lack of consistency between the studies when applying methods to measure EMG activity.

KEYWORDS: EMG; muscle activation; abdominal muscles; resistance exercises; strength; fitness

INTRODUCTION

Fitness is defined as a state of health and well-being, which is characterized by the ability to perform daily physical activities or exercise [1]. Thus, the primary purpose of strength and conditioning coaches is to prescribe the right physical fitness exercises to their athletes and/or clients in order to achieve specific fitness goals [2]. Several studies have provided information on the importance of core training and testing in several populations [3,4] in order to improve performance [5] and reduce the risk of injury (e.g., back and lower extremity injury) [6,7]. In addition, core physical fitness exercises may contribute to decreasing the risk of other musculoskeletal disorders (e.g., excessive load on lumbar spine, imbalance of hip extensors,

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atrophy of paraspinal muscles), which are the consequence of faulty postures and sedentary lifestyles [8]. The core is defined as an anatomical box which consists of several muscle groups, such as the rectus abdominis at the front, the internal and external obliques on the lateral sides, the erector spinae, lumbar multifidus, and quadratus lumborum at the back, the diaphragm at the upper edge and the pelvic floor, and the iliac psoas at the bottom [9,10]. From a practical perspective, the core muscles are the center of the body where most kinetic chains transfer forces to the extremities [10]. However, the transversus abdominis, lumbar multifidus, and quadratus lumborum are considered the key core muscles for fitness and health professionals [2]. In recent years, the development of surface electromyography (sEMG) has allowed us to measure muscle activation patterns [11]. These muscle activation patterns should be considered when selecting and prescribing physical fitness exercises [12], since the force of the muscle contraction is regulated by the totality of motor units recruited [13,14]. In addition, the recruitment of low- or highthreshold motor units depends on the intensity of the exercise [14]. Thus, the amplitude of the sEMG signal, which is frequently reported as raw (millivolts) or relative to the maximum voluntary isometric contraction (% MVIC), is commonly used to analyze levels of muscle activation and fatigue [2,15]. Given that the greater the electromyographic (EMG) activity, the greater the challenge to the neuromuscular system, it is suggested that the core exercises that increase EMG may be useful for core strengthening [2]. Sit-ups and curl-ups have, for a long time, been the most common core physical fitness exercises. However, new exercises have been developed by adding, for instance, unstable surfaces, such as Swiss balls, BOSU balls, or wobble balance board platforms in order to increase the proprioceptive demands of the exercises. In addition, a recent systematic review on the EMG activity during core physical fitness exercises considered that free-weight exercises may be recommended, since these multi-joint exercises are more time-efficient than core exercises on the floor or on unstable surfaces [2]. Nevertheless, research to date has been limited on which core exercises should be performed based on muscle activity patterns, and there is a discernible lack of consensus. The only review on core muscle activity in physical fitness exercises for healthy adults was published seven years ago, in which the authors concluded that fitness specialists should focus on free weight exercises (e.g., the squat or deadlift) rather than other specific core exercises in order to train these muscles [2]. However, this review only included studies that analyzed the muscle activity of three core muscles (the transversus abdominis, lumbar multifidus, and quadratus lumborum) [2]. In addition, new exercises have since been evaluated (e.g., the suspension plank, roll-out, body saw, pike, and knee tuck) so the literature is in need of an updated systematic review. Consequently, the aim of this study was to systematically review the current literature on the electromyographic activity in six core muscles (the rectus abdominis, internal and external oblique, transversus abdominis, lumbar multifidus, and erector spinae) during core physical fitness exercises in healthy adults.

Core Physical Fitness Exercises

The core exercises were based on prior classifications [2], these being: (a) traditional core exercises—low-load exercises which are usually performed on the floor in order to activate

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superficial muscles (e.g., the sit-up and back extension); (b) stability exercises—low load and low range of motion in order to activate deep core muscles (e.g., the front plank and side plank); (c) ball/device exercises—a combination of stability and traditional core exercises which might add unstable surfaces or devices (e.g., a crunch on a Swiss ball and the front plank on suspension systems); and (d) free-weight exercises—the addition of greater loads which tend to activate the upper or lower body and core muscles (e.g., the squat, deadlift, and shoulder press).

Assessment of Evidence Summary—Strength of Evidence

The strength of evidence was assessed exclusively for comparisons among exercise types and was not summarized for different exercises within the same exercise type. The criteria used to assess strength of evidence were adapted from criteria that were developed for use with randomized controlled trials. The evidence was graded as either strong, moderate, limited, or no evidence as follows: Strong evidence: generally consistent findings observed among 3 or more high-quality studies. Moderate evidence: generally consistent findings observed among 3 or more low-quality studies. Limited evidence: 1 study (either of low or high quality) or inconsistent findings observed among at least 4 studies. No evidence: no available studies.

Quality Assessment

The Effective Public Health Practice Project (EPHPP) scale was used to assess the level of evidence of each study. Currently, there is no standard scale for the methodological quality assessment of observational investigations on EMG. However, each study was assessed based on the EPHPP scale, which has been used as a standard tool for the assessment of methodological quality in previous research with similar aims. In addition, the use of this scale may decrease the risk of bias when interpreting the results from this systematic review. The EPHPP scale has six components (selection bias, study design, confounders, blinding, data collection method, and withdrawals/dropouts) categorized by three ratings (weak, moderate, and strong). The level of evidence of each paper may be weak (two or more weak ratings), moderate (one weak rating), or strong (no weak ratings). Once the studies were included in this systematic review, two reviewers rated each study. If there was any hesitation or question related to one of the components being rated, the reviewers discussed: oversight (final decision: strong), different criteria interpretations (final decision: moderate), and different study interpretations (final decision: weak).

Rectus Abdominis

Free-weight exercises elicited the greatest EMG activity in the RA during the unstable Bulgarian squat (unilateral) and the regular back squat (bilateral) with six maximum repetitions. The RA demand increased throughout the repetitions, suggesting that the difference between the Bulgarian squat and the regular back squat would increase as the muscle became fatigued. The fact that these exercises achieved the highest EMG activity in the RA might be explained not only by the heavy weights leading to exhaustion but also to the biomechanics of these exercises themselves. The trunk tilts forward during the squat phase to compensate for the hip moving further backwards and, consequently, the EMG activity increases. Core exercises on a ball/device, such as the roll-out plank and the suspended front plank were also recommended for

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achieving high RA activation. Suspension training systems add instability to the exercise, potentially leading to increased EMG activity. Also, it is essential to highlight that EMG activity may vary depending on the type of suspension training system used. For example, a previous study showed that pulley-based suspension systems elicited the greatest RA activation. This type of suspension system may require greater postural control and strength requirements to perform the exercise with the proper technique than other suspension systems. It is also important to consider where the instability is added. For example, one study found that the greatest EMG activity was observed when adding instability with the BOSU, not only on the feet but also on the lower back during the sit-up exercise. Since the RA is a trunk muscle, generating upper body instability would require greater activation to maintain postural control.

Internal Oblique

The front plank with scapular adduction and posterior pelvic tilt, which belongs to the core stability exercise group, may be recommended for developing IO activation. This isometric exercise showed the greatest activation values in the IO, perhaps due to the influence of the thoracolumbar fascia. The IO is attached to the thoracolumbar fascia, and this plays an essential role in the transmission of load from the trunk to the shoulder and the arm. In addition, the climax laughter exercise showed the highest mV values (~0.11 mV) [31]. This exercise, whose IO EMG activity was significantly greater than in the crunch exercise, requires high levels of internal muscular control. Consequently, it is recommended as a core stability exercise for IO activation as well as for its psychological and hormonal benefits. Although only a few studies have examined IO activation in free-weight exercises, kettlebell swings with the "Kime" variant registered the greatest EMG activity. The "Kime phase" involves a muscular pulse at the top of the kettlebell swing that trains quick muscle activation and relaxation. However, the same study showed that the large shear compression load ratio on the lumbar spine during the swing phase might be a reason to consider this exercise contraindicated in people with spine shear load intolerance.

External Oblique

Free-weight exercises, such as the Bulgarian squat, had the highest EMG activity. The fact that this unilateral exercise showed such EO activity could be explained by the aim of this trunk rotation muscle, which is to prevent lateral flexion. The exercise requires one foot in front of the other, and the greater the axial distance between them, the lower the stabilizing effect of the parallel legs and the greater the EO activity in preventing lateral sway. In addition, another unilateral exercise (the standing unilateral dumbbell press) had the greatest EMG activity reported as mV. A similar conclusion was drawn from this study—that the results may be explained by the EO's contralateral effect in stabilizing the core and postural sway when performing the exercise. In consequence, one can conclude that free-weight exercises are recommended for EO activation, especially those performed unilaterally due to the increases in EO activity. Another possibility suggested by this systematic review is the addition of a ball or device to the core exercises. For example, it suggested front planks on a Swiss ball with the variant of moving the forearms in a continuous clockwise fashion (stir-the-pot), or doing a hip extension while maintaining stability, as being very intense EO exercises. Adding stability balls leads to increased EMG [45,60,81]. Likewise, other researchers have observed increases in EMG activity in the EO when adding suspension training systems or whole-body wobble boards to the front plank exercise [45,78]. Since these instability systems challenge both proximal stability and distal mobility, exercises such as the front plank on a Swiss ball or stir-the-pot may be considered useful inclusions to core strengthening programs.

CONCLUSIONS

This study systematically reviewed the current literature on the EMG activity in six core muscles during core physical fitness exercises. The greatest activity in the RA, EO, and ES muscles was found in free-weight exercises. The greatest IO activity was found in core stability exercises, while traditional exercises showed the greatest MUL activation. However, there was a lack of research on TA activation during core physical fitness exercises and a lack of consistency between studies when applying methods to measure EMG activity. In addition, the level of evidence of the included studies was mainly moderate, which suggests that more high-quality research is necessary in order to the reduce the risk of bias and draw solid conclusions about core muscle activity.

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