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A Study Of Core Muscle Electromyographic Activity During Physical Conditions

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ABSTRACT—

The rectus abdominis muscle is involved in support, containment of viscera, respiration, defecation, urination, vomiting, and assistance during delivery. Many exe rcises and equipment are used to strengthen the rectus abdominus muscle, which aim to prevent and rehabilitate low back pain, improve athletic performance, or achieve aesthetic standards. Exercises that potentiate electromyographic activity require the recruitment of the biggest number of muscle fibers and are more effective in developing or maintaining strength. Analysis of electromyographic activity allows us to determine the quality of physical exercises for strength training, and to choose and order them properly in a training session. Electromyographic studies are required, with more rigorous methodological criteria, with the objective of reducing the risk of bias and obtaining definitive conclusions about muscle activity and identifying efficient exercises for the development of the rectus abdominis muscle strength. Ventral plank exercises present be tter electromyographic results for the rectus abdominis muscle and its action.

KEYWORDS— Abdominal Exercises, Electromyography, EMG, MVIC, Rectus Abdominis.

INTRODUCTION

The abdominal muscles are important in that they are directly related to body posture, containment of viscera, help during expiration, defecation, urination, vomiting, and assisting during delivery [1]. The rectus abdominis muscle is important for the positioning of the pelvis and is related to body posture by being indirectly responsible for the lumbar spine curvature [2]. Weakness of the rectus abdominis muscle can cause several disorders associated with posture, such as ptosis, low back pain, and respiratory disorders [3]–[6]. The rectus abdominis muscle is the main muscle of the anterior wall of the abdomen, characterized by being long and wide, similar to a lane, originating from the symphysis and pubic crest, inserting into the cartilages of the fifth, sixth, and seventh ribs, and xiphoid process of the sternum bone, separated from its homonym by the alba line [7]. The rectus abdominis muscle acts to increase intra-abdominal pressure, trunk flexion, and retroversion of the pelvis[8]. Exercises aimed at abdominal strengthening are widely practiced because they do not only involve aesthetic goals, but also prevent and rehabilitate low back pain, improve athletic performance, and increase resistance and trunk strength for daily activities [9]–[12] However, a consensus has not yet been reached on exercises that are effective in stimulating the activity of the abdominal muscles, especially the rectus abdominis muscle. Establishing a consensus on this topic would facilitate the dissemination and implementation of standardized training for strength training and physical conditioning, which could result in more effective multisite training programs, thus improving performance and avoiding injuries in athletes and/or patients. Decisions on which exercises should be performed in a training program are often based on opinions, personal experiences, and articles that may or may not be based on scientific evidence. Decision-making on which exercises are best under specific circumstances in such a way has led to the use of a wide variety of basic training techniques, with little or no consistency, among strength training specialists. Consequently, exercises that are best suited for activating the abdominal muscles and improving trunk strength are still much debated [13], and yet, there is no evidence-based consensus. Therefore, a systematic review with a consensus on the activity of the rectus abdominis muscle during physical exercises is necessary for specialists in physical conditioning and strength to prescribe appropriate protocols and recommendations to their athletes and patients. This systematic review aimed to analyze the activation of the rectus abdominis muscle based on the results obtained in electromyographic analyses during the execution of different physical exercises, as well as the morphological and functional characteristics of the volunteers and the technique used in the normalization of the electromyographic signal.

TRANSVERSE ABDOMINIS

Moderate Evidence.

Transverse abdominis EMG activity is similar during core stability exercises and ball/device exercises. One moderate-quality study 3 low-quality studies found no difference in transverse abdominis EMG activity between core stability exercises and ball/device exercises, whereas 1 moderate-quality study found that transverse abdominis EMG activity is greater during ball/ device exercises compared with core stability exercises.

Limited Evidence

Transverse abdominis EMG activity is greater during noncore free weight exercises compared with free weight exercises. One moderate-quality study found that transverse abdominis EMG activity is greater during noncore free weight exercises compared with free weight exercises.

Transverse abdominis EMG activity is similar during traditional core exercises and core stability exercises. Two moderate-quality studies found no difference in transverse abdominis EMG activity between traditional core exercises and core stability exercises.

Conflicting evidence was found regarding transverse abdominis EMG activity during traditional core exercises compared with ball/device exercises. One low-quality study found that transverse abdominis EMG activity is greater during traditional core exercises compared with ball/device exercises, whereas 2 moderate-quality studies found that transverse abdominis EMG activity is greater during ball/device exercises compared with traditional core exercises. One low-quality study (8) and 2 moderate-quality studies found no difference in transverse abdominis EMG activity between traditional core exercises and ball/device exercises.

No Evidence

No evidence was found regarding transverse abdominis EMG activity during the following comparisons: traditional core exercises with free weight exercises, traditional core exercises with noncore free weight exercises, core stability exercises with free weight exercises, core stability exercises with noncore free weight exercises, ball/device exercises with free weight exercises, and ball/device exercises with noncore free weight exercises.

MATERIAL AND METHODS

The systematic review protocol of the present study was developed in accordance with the items reported for systematic reviews of the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA-P) [14], [15] and registered in the International Prospective Review Record (PROSPERO) under number: CRD42018086172, [16]. 1) Study design It is a protocol for the systematic review of prospective cohort studies, following the guidelines of PRISMA-P. The entire process of study selection is performed by two reviewers and summarized in a PRISMA flow diagram. 2) Inclusion/exclusion criteria Cross-sectional studies, case studies, and randomized clinical trials published in English from January 2014 to June 2018 are included in this review. 3)Participants Healthy individuals who are able to practice physical exercises, aged between 18 and 60 years, were included. No restrictions of gender, ethnicity, or socioeconomic status was applied. We excluded studies with individuals who presented some factor that could interfere in the reliability of the results, such as pregnancy, fracture, osteoporosis, malformations, skeletal deformities, spondylitis/spondylosis, rheumatic diseases, equine tail syndrome, abdominal surgery, tumor, neuromuscular disorders, cardiopathy, neurological dysfunctions, alcoholism, smoking, myopathies, or neuromyopathies, low back pain, abdominal pain or any other type of clinical problem that could interfere with the execution of the proposed exercises. 4)Intervention Included interventions investigated the electromyographic activation of the rectus abdominis (RA) muscle, regardless of its part, being upper rectus abdominis (URA) or lower rectus abdominis (LRA), and which presented the electromyographic signal normalized by the percentage of maximal voluntary isometric contraction (MVIC%). 5)Results measures Studies that report the results of the of MVIC% and analysis of the electromyographic signal in the temporal domain of the abdominal musculature in different types of physical exercises are considered. We excluded studies that did not evaluate the MVIC% root mean square (RMS) or those not analyzing the EMG signal in the domain time of the RA muscle. The data collection tools include the analysis of the results obtained through EMG in the exercises performed.

RESULTS

Our search resulted in 3390 citations, and some duplicates were disregarded, leaving 1441 studies that examined the RA muscle. After analyzing titles and abstracts, 146 potentially relevant studies were selected. After analysis of the full texts, 13 studies are considered eligible and are included for further analysis. A total of 133 studies were considered ineligible, and 42 were excluded that did not study common exercises in physical training, that is, 19 did not clearly analyze the EMG of the RA muscle, 14 measured muscle activity with ultrasonography or magnetic resonance imaging, 2 were not published in the English language, 2 volunteers reported lesions or pain, and 54 EMG signals were not normalized.

DISCUSSION

An important finding of this systematic review is that the overall design quality of the included studies is good, but with a risk of methodological bias characterized by a systematic error in the procedures for sample selection and normalization of the EMG signal. Therefore, the evidence base for the EMG activity of the RA muscle during physical conditioning exercises studied is not strong despite its widespread use in physical training and rehabilitation communities. Despite the clear risk of methodological bias of the studies that are included in this review, the current data allow us to conclude that physical exercises are more effective in activating the RA muscle. Our findings indicate that the EMG activity of the RA muscle is higher during ventral decubitus exercises, with the trunk in elevation, known as "ventral plank," and is even greater, with the use of equipment that may generate instability, such as the Swiss ball and sling. Possible explanations for the increased activity of the RA muscle during unstable exercises include the increased need for the RA muscle to stabilize the spinal cord and protect the spinal cord, demonstrating the stabilizing functional characteristic of this muscle. Even with the greater tendency of muscular action in ventral plank exercises, no specific type of exercise is considered to be clearly effective for the development of RA muscle strength in this systematic review. The comparisons between the types of exercises show that the findings are conflicting becaus e the values are between 21% and 43% of MVIC for the same exercise, such as the ventral plank, on a stable surface, in the different studies. Escamilla [32]et al. (2010) classified muscle activity level into low (0% to

20% MVIC), moderate (21% to 40% MVIC), high (41% to 60% MVIC), and very high (above 60% MVIC). Exercises that produce muscular activation >60% of MVIC can be directed to muscle strength training, which evidence the low activity of the RA muscle in the exercises analyzed in this review. In the exercises performed using equipment to generate instability, the EMG values presented ranged from 28% of the MVIC [18] to 141%, suggesting a lack of criteria and quality in strategies of EMG signal normalization, using manual resistance. Being that in a test of voluntary isometric maximum contraction, it should have, at most, 100% of the muscular capacity, making values >100% impossible. To produce a “real maximum” activation, a good fixation of all involved body segments is very important. Untrained individuals may have trouble producing a true level of contraction in the MVIC test. Machines with fastening belts should be used whenever possible. It is interesting to note that, depending on the volunteer's ability to coordinate, different MVIC tests (exercises and different positions) may produce higher MVIC values. Especially for trunk muscles, trying two or three exercises and checking which could have the highest level of EMG signal may be necessary. When manual resistance is used in MVIC tests, it is believed that there is no “peak” activation of the analyzed muscles, leading to lower MVIC values and, automatically, excessive values in the exercises. Therefore, future studies should prioritize the MVIC protocol with fixed resistance to facilitate the understanding and practical application of the results. The studies included in this review demonstrate characteristics that limit the quality of the results, presenting a strong methodological bias associated with factors, such as the lack of information on the fat percentage of the volunteers, which are present only in the studies of low training time, small samples, little or no familiarization of the volunteers with the proposed exercises, different inclusion and exclusion criteria, as well as lack of discussion about how safe the exercises are, and grouping and summarizing data that understanding the results difficult.

The surface EMG signal amplitude and frequency characteristics have been shown to be sensitive to intrinsic (muscle fiber type, depth, diameter, electrode location, amount of tissue between muscle and electrode) and extrinsic factors (location and orientation about the area and shape of the electrodes, and the distance between them). Therefore, the amplitude of the EMG signal cannot be analyzed directly, making it necessary to use a more robust methodology that investigates and standardizes the volunteers morphologically, the percentage of fat, possibly the thickness of the skin fold in the place of fixation of the electrodes, studying individuals trained in the proposed exercises, application of more than one electromyographic evaluation, allowing the observation of the muscular adaptation at the end of a training. Given the limitations of available scientific literature on this subject, the physical training specialist should review individual studies with caution when interpreting the results for practical applications. We suggest new research using EMG to elucidate the real contributions of the exercises used in gymnasiums and physical training centers for the development of RA muscle strength, bringing the practice methodology closer to the training environment, thus seeking greater validity externality of the information presented, allowing adequate selection and order of the exercises proposed by the coaches, improving the strength training of the RA muscle for different goals and sports modalities.

CONCLUSION

The need for electromyographic studies, with more rigorous methodological criteria to reduce the risk of bias and to obtain definitive conclusions regarding muscular activity and to identify efficient exercises for the development of RA muscle strength. Ventral plank exercises present better EMG results for the RA muscle and its action. The muscle is more required when its activity is associated with instability, but the following should be considered: a) adequate normalization of the EMG signal through equipment that effectively identifies MVIC, b) the morphological characteristics related to the percentage of body fat, c) volunteer familiarization with the proposed exercises. Improved research in this area should provide strength training and fitness specialists with additional evidence-based expertise to enable the prescription of basic exercises appropriate to athletes and patients.

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