Editorial

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Core muscle activity in exercise

Abstract

Core region; It is defined as an anatomical cylinder consisting of the rectus abdominis in front, internal/external obliques on the sides, erector spinae, lumbar multifidus and quadratus lumborum in the back, diaphragm on the upper edge, pelvic floor and iliac psoas on the bottom. The core is the center of the body where the kinetic chain transfers forces to the extremities. Strengthening the core muscles with exercise programs is effective in the treatment of musculoskeletal problems and prevention of injuries. With the development of surface electromyography, muscle activation can be measured in different patterns and has been widely used. With this application, core muscle activity can also be determined during exercise. In conclusion, this article reviews the current literature on the electromyographic activity of six core muscles including rectus abdominis, internal/external oblique, transversus abdominis, lumbar multifidus and erector spinae during core exercises in healthy adults.

Keywords: core muscles, core stabilization, exercise, muscle activation

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Ferhan Soyuer,[1] Merve Koku[2]

[1]Department of Physiotherapy, Turkey

[2]Research Assistant, Cappadocia University, Department of Physiotherapy, Turkey

Correspondence: Ferhan SOYUER, Department of Physiotherapy, Turkey, Email soyuerferha@gmail.com

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Introduction

In recent years, with advances in electro-physiological measurement techniques, sensors, etc., surface electromyography (EMG) has been developed and with these developments, muscle activation in different patterns can be measured.[1] The EMG signal, often recorded in raw (millivolts) or maximum voluntary isometric contraction (% MVIC) is also widely used to analyze muscle activation levels.[2]

The strength of muscle contraction is related to the intensity of the motor unit involved.[1] The activation of low/high threshold motor units depends on the intensity of the exercise.[2] Therefore, when determining appropriate exercises, it has become important to have EMG muscle activations determined in different patterns.[3] The Core region, defined as the connection between the upper and lower extremities, consists of the abdominals in the front, para-spinals and gluteals in the back, diaphragm on top, hip girdle and pelvic floor muscles at the base. Studies have shown that loss of strength in the core region has negative effects on balance, flexibility, etc. in individuals.[3] Core strengthening programs have become popular in recent years.[4] However, there is limited literature and lack of consensus on which core exercises should be performed based on muscle activity patterns.[5] Therefore, in this short review, EMG activities of six core region muscles including rectus abdominis (RA), internal (IO)/external oblique (EO), transversus abdominis (TA), erector spinae (ES) and lumbar multifidus (LM) were reviewed in healthy adults during exercise.

Core zone

The term core means core of English origin.[3] In the field of health, the term core has also been defined as the center of gravity, the lumbo-pelvic region, which is considered the midpoint of the human body.[4] The core is an anatomical cylinder consisting of rectus abdominis in front, internal/external obliques on the sides, erector spinae, lumbar multifidus, quadratus lumborum and gluteal muscles in the back, diaphragm on top, pelvic floor and muscles, ilio-psoas muscle groups below.[4] These muscles act as muscle corsets on the trunk and spine, which stabilize the body and spine/pelvis with or without limb movement, and play an important role in postural stabilization.[6]

Core muscles

It consists of 29 pairs of muscles that help stabilize the spine, pelvis and kinetic chain during functional movements. Superficial to the core are the global mobilizer muscles responsible for movement and power generation, while deeper in the core are the local muscles that control movement by contracting eccentrically and are responsible for static stabilization and proprioception. Today, this classification is widely used and forms the basis for core stabilization exercises.[6] Global muscles are divided into fast-twitch superficial muscle groups (rectus abdominis, external obliques, quadratus lumborum, psoas major and erector spinae) and local muscles; slow-twitch deep muscle groups (transversus abdominis, multifidus, internal oblique, deep transverso-spinalis and pelvic floor muscles).[7]

The leading muscles of the local muscles are the multifidus and transverse abdominis, and among the global muscles, the m.rectus abdominis. Among the abdominal muscles, m. transversus abdominis is the most important muscle in terms of stabilization.

The multifidus muscle contributes to segmental stabilization and proprioception of the vertebral column. Co-activation of the transversus abdominus and multifidus leads to efficient movement and dynamic trunk stability through fascial connections from the trunk to the extremities.

m. Quadratus lumborum (QL) is one of the most important lateral stabilizers of the spine. It is involved in the local and global musculature. The task of M. Quadratus Lumborum in the local system is to provide lateral stability of the spine, while its task in the global system is to limit the contraction of the diaphragm. The diaphragm muscle forms the roof of the core region and increases intra-abdominal pressure with simultaneous contraction of the pelvic floor and abdominal muscles, providing stronger trunk stabilization.[8] The pelvic floor muscles form the base of the core. It consists of the levator ani group (iliococcygeus, pubococcygeus and pubotectalis) and the coccyx. These muscles work synergistically with the transversus abdominus, abdominals and multifidus muscle to form the base of support for the trunk muscles.[9]

Core stabilization

There is no internationally accepted definition for the concept of core stabilization. A functional definition is defined as the basis of the kinetic chain that provides moment and torque transfer between the upper and lower extremities during exercise, sports and activities of daily living. Core stability is defined as the ability of passive/active stabilizers in the lumbo-pelvic region to balance and control, providing

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proper trunk and hip posture during static/dynamic movements. It is based on co-activation, coordination and sensori-motor control of the trunk muscles.[10]

Core stabilization is provided by three basic structures:[11]

I. Neuro-muscular control (central nervous system)

II. Passive subsystem (bones, joints and ligaments)

III. Active subsystem (muscular system)

Core area basic exercises

Exercise programs should include strength, balance, flexibility, endurance, endurance, limb function and functionality in order to stabilize the core and lumbo-pelvic region.[9]

Core exercises can be grouped as follows;

Traditional core exercises; low-weight exercises usually performed on the floor to activate superficial muscles (e.g. sit-ups, lumbar extension)

I. Stability exercises; low load and range of motion to activate deep core muscles (e.g. front plank/lateral plank),

II. Exercises with the ball/devices; given on unstable surfaces and with additional devices, combinations of stability and traditional core exercises (with a swich ball and suspension systems),

III. Free-weight exercises; larger weight loads (squats, deadlifts and shoulder presses) to activate upper/lower body and core muscles.

There is no consensus on the most effective exercise model for strengthening core stabilization. In the first stage, it is recommended to strengthen local muscles and then create a progressive program by adapting the exercises to whole body dynamic movements in different positions.[12] Because core exercises cause both structural changes in muscles and neural adaptation.[8] In addition, these exercises, which are used as dynamic/static exercises are more effective in providing muscular recovery and body control by improving proprioceptive sensations, thus improving the balance and strength of the core region.[11]

EMG activities of core muscles during exercise

M. Rectus Abdominis (RA)

Among the traditional core exercises, the static curl-up with hands behind the neck, hips at 60° and knees flexed at 90° was shown to elicit the highest EMG activity in RA (81.00, 10.90% MVIC). Static curl-ups with arms crossed over the chest, hips at 60° and knees flexed at 90° (67.60% 15.70% MVIC) ranked second.[13]

In studies reporting EMG activity in mV for the RA muscle, the highest values were obtained in unstable sit-ups on a bosu ball (Upper RA: 0.33 ± 0.14 mV; Lower RA: 0.65 ± 0.33 mV).[14] Among free weight exercises, the greatest EMG activity in the RA was recorded during unbalanced Bulgarian squats (unilateral) and normal back-back squats (bilateral) with six maximal repetitions.[13] For high RA activation, core exercises on the ball/device are also recommended.[14,15]

M. External Oblique (EO)

EMG activity of the EO muscle has been recorded high in free weight exercises such as Bulgarian squats.[16] To increase EO activation, it is also recommended to perform free weight exercises unilaterally and to add a ball/device to core exercises.[17] The curl-up traditional core exercise with the hip in 900 flexion showed the highest EMG activation (with maximal expiration: 70.74% 20.57% MVIC; with slow expiration: 65.18% 24.83% MVIC). Moreover, sit-up exercise reached ~0.41 mV.[16] Within the core stability exercises, scapular adduction, front-plank with posterior pelvic tilt elicited the highest EMG activity (110.78% 65.76 MVIC). Furthermore, front-plank with additional weight (20% body weight) reached ~0.2 mV. Adding stability balls caused an increase in EMG in the m.EO muscle. Other studies have also observed increases in EMG activity when adding suspension training systems to front-plank exercise.[18]

M. Internal Oblique (IO)

Among the traditional exercises, the static curl-up exercise with hands behind the neck, hips at 60°, and knees flexed 90-45° was the exercise with the highest % MVIC. Crunch was the exercise with the highest mV values in the m.IO muscle (~0.08 mV).

Among core stability exercises, scapular adduction, posterior pelvic tilt and front-plank showed the highest % MVIC (119.92 % 60.26 MVIC) for m.IO, while climax laughter exercises showed the highest mV values (~0.11 mV).

The core exercises with the device and ball that show the greatest activity in m.IO are front-plank with hip extension (76.50% 37.00% MVIC) and front-plank on a swich ball with stir-the-pot (73.50% 31.30% MVIC) (Mori, 2004).

There are studies that recorded the highest EMG values for m.IO during free weight exercises in kettlebell swing (80.80%, 43.70% MVIC) and unilateral bench press (~0.05 mV). Scapular adduction, posterior-pelvic tilt and front-plank, which are core stability exercises, can also be recommended to increase m.IO activation.[19]

M. Transverse Abdominis (TA)

The greatest activation of this muscle has been reported in suspension training systems using sling exercise, side-lying lumbar setting. It has been explained that sling exercise, which can be performed in prone, supine, side-lying positions, improves the activation of local trunk muscles such as m.TA and LM.[20] Despite the higher EMG activity of m.TA in the side lying position, prone and supine sling exercises have also been recommended to stabilize the lumbar region due to the high local/global muscle ratio.[21] Of the core stability exercises, bird-dog specifically has been shown to elicit more EMG activity in the m.TA than in the m.IO/LM; this is because the m.TA is the primary trunk stabilizer modulating intra-abdominal pressure, tension of the thoraco-lumbar fascia and compression of the sacro-iliac joints.[22] Studies examining m.TA activation based on % MVIC found that in a sling exercise, side-lying-lumbar setting showed the highest activation (58.65% 6.99%), followed by static curl-up exercise with hands behind the neck (40.70% 26.50%).[23]

M. Erector Spinae (ES)

Free weight exercises (deadlift, hip-thrust, back-squat) elicited the greatest m.ES activation. Among traditional core exercises, back extension exercises at the floor elicited the highest m.ES activation (~63% MVIC).[24] One study showed that m.ES activity was higher in the hyperextension phase of the movement compared to other exercise phases. A variant of this exercise, one-legged back extension, also increased EMG activity in ES and has been recommended as a core physical fitness exercise.[25] Suspended bridge exercises also showed very similar EMG activities in m.ES. Among core exercises on a ball/device, suspended bridge showed the highest % MVIC (61.51%/13.85%), while among free weight exercises, high activation was found in dead-lift, hip-thrust and back-squat (barbell deadlift: ~90% MVIC).[26]

M. Lumbar Multifidus (LM)

The highest % MVIC for this muscle was observed in traditional exercises during active lumbo-pelvic control and prone trunk extension, prone leg extension.[26] One of the core exercises on a ball/device, the hip extension exercise with front-plank on a swich ball, is recommended to improve m.LM activation as it is the highest % MVIC for m.LM. In the static front-plank on the ground, the addition of the unbalancing ball elicited more EMG activity.[25] For core stability, the highest m.LM activation % MVIC was found in bridge exercise and bird-dog (~39%). The highest mV value was also observed in bird-dog (0.86 1.01 mV). Among free weight exercises, the highest EMG activity was found in flex at 45% of body weight.[27,28]

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Conflicts of interest

The author declares there is no conflict of interest.

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