Ten Important Facts About Core Training

Article *in* ACSM s Health & Fitness Journal · January 2019

DOI: 10.1249/FIT.0000000000000449

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TEN IMPORTANT FACTS ABOUT CORE TRAINING

by Cauê V. La Scala Teixeira, M.Sc.; Alexandre L. Evangelista, Ph.D.; Marta Santos Silva; Danilo Sales Bocalini, Ph.D.; Marzo E. Da Silva-Grigoletto, Ph.D.; and David G. Behm, Ph.D.

Apply It!

- Isometric exercises performed with the spine in the neutral zone should precede (anticipatory activation) the dynamic exercises in a training program, because one of the functions of core training is to improve stability for subsequent movements to be more efficient.
- Training programs should use all movement dimensions (isolated or combined), including exercises that emphasize the serape (muscles involved with shoulder and trunk rotation) effect to enhance rotational movements.
- The use of unstable bases and loads in the exercises can be an effective strategy to increase the level of neuromuscular activation of trunk-stabilizing muscles.
- The implementation of multijoint exercises such as Olympic lifts or kettlebells can integrate core recruitment with the entire posterior chain.

Key words: Functional Training, Core Stability, Strength Training, Resistance Training, Spine

BACKGROUND

The word "core" means the central region or the most important part of a component. In the human body, the core is the central region of the body, comprising the pelvic girdle, trunk, and scapular region. This region has dozens of muscle groups with functions, such as ensuring the integrity of the spine and vital organs during postural maintenance and body movements, maintaining body balance during static and dynamic tasks, and transferring forces between lower and upper limbs (1–3). The core works as an integrated functional unit, whereby the entire kinetic system — a system of active (*e.g.*, muscles) and passive tissues (*e.g.*, tendons, fascias) that act simultaneously producing and transferring forces during motor tasks — works synergistically to dynamically produce force and stabilize the body. This integrated and interdependent system needs to be properly trained to allow its function in day-to-day as well as athletic activities (4,5).

Although training the muscles of the central region of the body has been a recommendation in the classic sports training literature for many decades (6,7), the increase in practical and scientific core training is more recent (8). Currently, core training, as well as functional training, has been used in exercise programs aimed at quality of life, health, and the improvement of back pain (9,10).

The recent increase in the quantity and quality of scientific publications about core training involving different approaches, exercises, implements, and populations has provided an amplification of the specific knowledge about this type of intervention. Thus, our objective is to highlight 10 theoretical-scientific points about core training in a practical language to avoid the dichotomy between theory and practice.

1. *Local and global muscles:* The core region has 29 pairs of muscles classified according to their location, architecture, the proportion of muscle fiber types, and function. The classification most commonly used in the literature groups the core muscles into two classes (Table 1): local and global muscles (11,12). The local muscles are

TABLE 1: Local and Global Muscles (Systems)

Local Muscles	Global Muscles
Multifidi	Rectus abdominis
Transversus abdominis	Lateral fibers of external oblique
Internal oblique	Psoas major
Medial fibers of external oblique	Erector spinae
Quadratus lumborum	Iliocostalis (thoracic portion)
Diaphragm	Gluteus
Pelvic floor muscles	
Iliocostalis and lognissimus (lumbar portions)	

deep, adjacent to the spine (*i.e.*, erector spinae), mostly aponeurotic — non-fusiform muscle, whose connection to the bone (origin, insertion) has no tendon but connective tissue in a flat shape — with a greater proportion of type 1 (slow twitch) muscle fibers playing a stabilizing role. On the other hand, the global muscles are the superficial muscles (*i.e.*, latissimus dorsi and others) that are generally fusiform, have more type 2 fibers (fast twitch), and act, mainly, to generate torque and joint movement (13). These muscles create the foundation of the kinetic chain/system responsible for managing the transfer of torque and dynamics between the lower and upper limbs of the body, whether for the tasks of daily living, exercise, or sport. Because the stability of the spine depends on the synergistic and integrated action of local and global muscles (functional muscle unit), the core training program should contain exercises with co-contraction, as well as different characteristics (*e.g.*, statics and dynamics, strength and muscle endurance). A good example is the "bracing" — activate the abdominal muscles as you would if you were about to be punched in the stomach, keeping your breath free — exercise that stimulates integrated and synergic action of all abdominal muscles (full abdominal muscle cocontraction) (14). Another technique that will produce a natural bracing action is to get into a push-up position from the feet or a forearm plank keeping spine neutral and supported.

2. *Neutral zone of the spine:* The spine presents a small degree of freedom of three-dimensional movements in which the tension on passive (noncontractile) structures is minimal or practically nonexistent (Figure). This degree of freedom in which movements are performed without generating tension on noncontractile structures is known as the neutral zone, and it has a three-dimensional amplitude of approximately 2 degrees (15,16). One of the goals of core training is to improve the ability of the stabilizing muscles to keep the spine within the

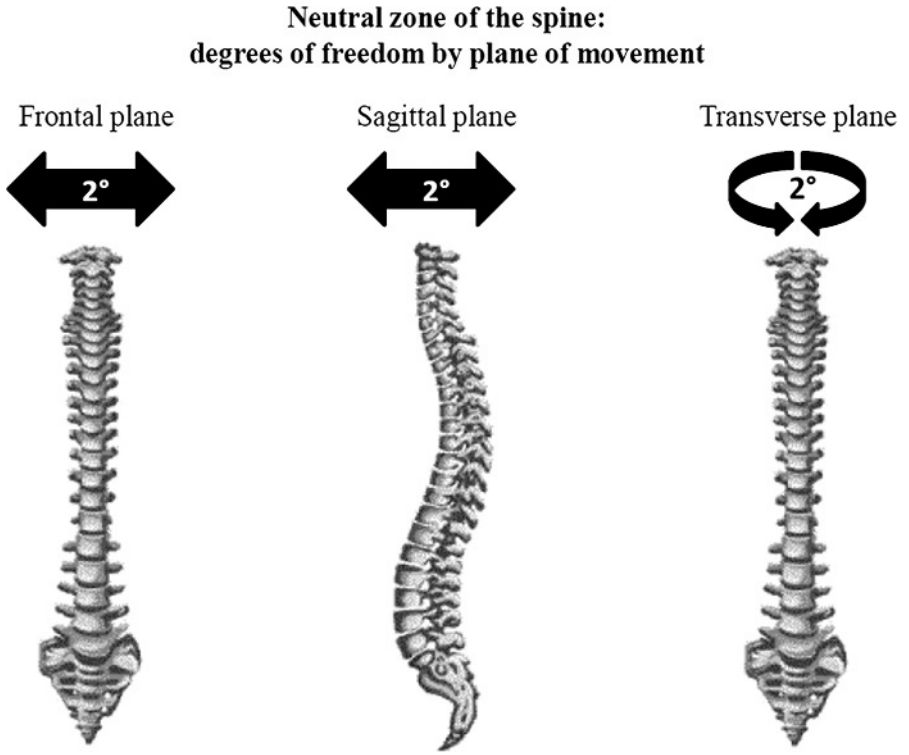

Figure Neutral zone of the spine and its three-dimensional degrees of freedom.

neutral zone, even when facing the incidence of external forces in the region, for example, by sitting for long periods (maintaining the natural anatomical curvatures of the spine under exposure to force of gravity) or by performing exercises with longitudinal and transverse loads on the spine (*e.g.*, squat, stiff-leg deadlift).

3. *Anticipatory activation:* In an individual who has a normal neuromuscular function, the local muscles are activated before performing limb movements (17). For example, when standing on a chair, the nervous system recruits the transverse abdominus before recruiting the quadriceps. The idea is to keep the spine rigid (stable) so limbs move efficiently (high speed, high accuracy, and low-energy use). However, in people with low back pain (LBP), this pattern of anticipatory activation of the core muscles is impaired; that is, the muscles have their activation delayed or inhibited (18). In this case, late activation, especially of local muscles, will predispose the person to pain, because movement will occur without stabilization. One of the functions of core training is to re-educate (in people with LBP) and improve (in people without LBP) this pattern of anticipatory activation of the local muscles. Re-education exercises can involve a variety of activities. Anticipatory strength can be enhanced by implementing unilateral resistance exercises (*i.e.*, unilateral shoulder presses, bicep curls, calf raises, and squats) that force the system to anticipate the resistive torques applied to the core (trunk) muscles (19–21). Further anticipatory strength adjustments can be improved by using unstable bases to disrupt balance and ensure the system applies compensatory contractions (20–24). These balance and stability challenges can be amplified with eyes closed to place more emphasis on the proprioceptive system or with greater resistances (*i.e.*, dumbbells, barbells, elastic bands) to magnify the resistive torques (20,21). Finally, greater progressions can be achieved by making the exercises more dynamic with higher velocities by adding hopping, bouncing, jumping, bounding, and other similar activities on both stable (*i.e.*, floor, ground) and unstable surfaces (*i.e.*, sand or undulating surfaces) (25–27).

4. *Stabilize and then move:* Although the dynamic exercises for the core are the most popular, they have little transfer capacity; that is, they contribute little to improve the stability of the trunk in everyday situations or sports. Considering that in most of the movements of daily activities and sports the spine remains erect, even when limbs move, isometric exercises seem to be more productive to improve trunk stiffness and postural function (28). Thus, isometric exercises performed with the spine in the neutral zone should precede the dynamic exercises in a training program, because one of the functions of core training is to improve stability for subsequent movements to be more efficient.
5. *Three-dimensional stability:* During most daily tasks, labor, or sports, the human body undergoes balance disturbances coming from the external and internal forces that affect it. As the forces acting on the body come from different factors (*i.e.*, gravity, movement of the body or part of it, lifting or support of external loads, muscular contractions), they destabilize the body in the three dimensions (sagittal, frontal, and transverse) (29). Thus, a training program should explore exercises in all movement dimensions, isolated or combined, because one of the functions of core training is to improve the tridimensional stabilization capacity of the trunk (30).
6. *The powerhouse has a floor, walls, and a ceiling:* Although the core comprises the whole trunk region, the most frequent approaches in the literature highlight the lower trunk, mainly due to the high incidence of LBP in the world population and the strong association between LBP and lack of conditioning of the musculature adjacent to the lumbar spine (31,32). Thus, it should be understood that the core, also known as the "powerhouse," has muscles forming its structure of floor, walls, and ceiling. In this context, special attention should be given to the training of all core muscles, including those that tend to receive less attention in traditional training programs such as the pelvic floor, the transverse abdominus muscles, and the diaphragm, these being among the challenges of core training programs (33).
7. *Instability:* Disturbance of the body's center of gravity leads to sudden changes in the position and length of muscles, which stimulates proprioceptors, generating reflexive muscular activation. Confirming this idea, the use of unstable bases (*i.e.*, Swiss ball, BOSU, foam pads, wobble boards) in the exercises has been shown to be an effective strategy to increase the level of neuromuscular activation of trunk-stabilizing muscles (34). In addition to

TABLE 2: Example of Exercises in Specific Categories

Specific Categories	Exercises
Coactivation exercises (points 1 and 6)	Exercises that stimulate simultaneous contractions of several core muscles (*e.g.*, bracing, pelvic floor exercises)
Isometric exercises (points 2 and 4)	Exercises that require maintenance of static postures for a fixed time (*e.g.*, plank, hip bridge, side plank, opposite arm, and leg lift)
Dynamic exercises (point 4)	Exercises that require movement of the spine, pelvis, and hips (*e.g.*, crunch, curl-up, back extension, lateral flexion, trunk rotation)
Three-dimensional stability exercises (point 5)	Exercises that stimulate core stability in the three planes of movement (sagittal, frontal, and transverse) in an isolated or integrated approach (*e.g.*, several types of plank, unstable exercises)
Instability exercises (points 2, 3, and 7)	Exercises that challenge the maintenance of body balance (*e.g.*, exercises in a standing position, with feet movement [*e.g.*, forward and reverse lunges], over unstable surfaces [Swiss ball, BOSU], with unstable loads [kettlebell], unilateral or alternating [unilateral shoulder press, unilateral alternating bench press], with occluded vision)
Weightlifting exercises (points 2, 3, 8, and 9)	Exercises involving the lifting of high loads (resistance) at high intentional speed of movement (*e.g.*, clean and jerk, snatch, deadlift, squat, swing)
"Serape" exercises (point 10)	Exercises that involve oblique movements away or approaching the opposite hip and shoulder (*e.g.*, crunch with rotation, wood chop, lift and chop)

unstable bases, the use of unstable loads (*i.e.*, elastic, kettlebells) also increases the activation of stabilizer muscles of the trunk, the scapular, and pelvic girdles. Activating stabilizing muscles is one of the functions of core training and therefore instability can be an interesting tool for this purpose. Reassurances should be made when the primary goal of training is to improve strength, power, and speed. In such cases, instability should not be the primary resource; alternative strategies can be seen in point 8.

8. *Basic and Olympic lifting/swings:* In sports that necessitate training for high performance as well as advanced training, core stability should be developed together with other physical abilities considered determinants of performance, such as strength and power (35). For this, isolated training of the different components of physical fitness may be an option, but in general, it is less effective than the integrated and synergistic training of physical abilities. In this way, well-trained athletes and individuals benefit from the practice of integrated exercises that, because they present characteristics that include high movement complexity, high loads, high execution velocity, acceleration, and deceleration, also present great potential to synergistically improve strength, power, and core stability. The main examples of exercises with these characteristics are the basic lifting (squat, deadlift) and mainly Olympic lifting (snatch, clean, and jerk) exercises. In addition, there are global exercises using a kettlebell, where it is possible to perform several exercises such as swing and snatch. These exercises provide a moderate-to-high activation of the core muscles, especially when performed unilaterally, in which approximately 70% to 80% of the maximum voluntary isometric contraction of the gluteus medius muscles (ipsilateral) and the obliquus internal muscles (contralateral) are required (36). As in sporting situations, high levels of core stability are required in situations necessitating high strength and power, the core training can and should contemplate multijoint exercises with the use of bars or kettlebells to integrate core recruitment with the entire posterior chain (which includes the hamstrings, gluteals, erector spinae, among other muscles). However, it should be noted that these exercises should be part of a more advanced progression of core training; that is, the subject must previously be able to consciously activate the stabilizing muscles that will protect his or her spine from the compression and shear forces caused by these exercises.

9. *Unilateral and/or alternating exercises:* Just as traditional weightlifting exercises are good options for developing core stability in situations in which power and force increase are desired, another viable strategy is the unilateral execution of resistance exercises in the frontal (*e.g.*, shoulder press) and transverse (*e.g.*, bench press). The unilateral execution leads to the projection of the center of gravity to the side on which the external load is mobilized, contributing to the increase of contralateral core musculature activation (37,38). Similarly, the execution of unilateral exercises alternately between the limbs also can be applied for this purpose because of the greater changes generated in the position of the body's center of gravity in the bilateral/simultaneous execution.
10. *Serape effect:* The rhomboid, anterior serratus, and outer and inner oblique muscles together form a belt-like structure, similar to a Mexican garment called a "serape." By rotating the shoulders (upper trunk) and pelvis (lower trunk) in opposite directions, these associated muscles are prestretched diagonally. This prestretch, known as the "serape effect" in the literature, provides the benefits of the stretch-shortening cycle, which potentiates maximum power/force output (39). From a practical point of view, the "serape effect" occurs in ballistic movements and activities such as kicking and throwing. Thus, exercises based on this type of movement can be explored when improving performance for sports activities that require rotational movements (fights, swimming, shooting, tennis, etc.) (Table 2).

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Disclosure: *The authors declare no conflict of interest and do not have any financial disclosures.*

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BRIDGING THE GAP

Core training is an essential component of resistance training and has received much greater emphasis lately. The core contributes to a kinetic chain transferring forces, torques, and power between the lower and upper limbs. Among the goals of core training are to improve the stabilization of the spine through greater strength, endurance, and the anticipation of body movement. Enhanced strength can be attained with combinations of isometric contractions, three-dimensional movements, unstable loads, Olympic-type lifts, the use of kettlebells in swinging and lifting actions, and unilateral resistance exercises.