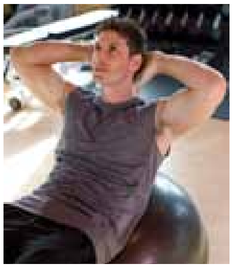

Evidence for Core Training: What Works and for Who?

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Core training comes in all shapes, sizes and ranges from the traditional sit-up, to the insane and eccentric. Much of core training has evolved into what has been called stability training or functional training. Some have claimed that much of what core training has evolved into falls short of "functional." That is, if functional is intended to mimic or simulate sport/competition-like conditions. For example, there are not many athletes who complete or practice on surfaces that are round and unstable. On the other hand, it is as equally unfair to relegate "functional" to mean only those activities which mimic the exact conditions of a given sport. That being said, core (including functional or stability) training is an integral piece to all performance enhancement programs. The purpose of this article is twofold; 1) review and critique the evidence for core training, and 2) raise thought-provoking questions for future research on core training.

Master builders have long proclaimed that, "form follows function." This is also true when building athletes. When "building" athletes it is important to keep this axiom in the forefront of our minds by asking, "what demands are being placed on my athletes?" When considering this question, the idea of functional can be extrapolated to be more than just mimicking the mechanics of a movement or skill. Although that is an aspect of function, mechanical movements and skills are only one aspect of function. Function can have many meanings within the context of sport performance—enter the concept of core training. Core training is closely related to functional training (although not synonymous) and a strong core is fundamental to function. An athlete who has core strength, or stability, can change directions more efficiently, has a greater capacity to accelerate and decelerate, has less "disruptions" in the transfer or dissipation of power through the kinetic chain, and among other things, can better manage stress to the lower back.

Just about every activity in our "non-athletic" daily routines requires core strength and stability in some form—and I am sure that every sport, activity or performance requires core strength. However, that is not to say that to be successful in sports, every athlete should be able to do 1,000 hanging crunches while squeezing a medicine ball between their knees or balance squat on a stability ball. In other words, core training is not exempt from thoughtful critique. When taking an evidence-based approach to core training, it is important to ask, "is there a threshold? Or, at what point is sufficient core strength achieved?" In other words, if core strength is a prerequisite for high performance is there an "extra" benefit for an athlete who can do 1,001 perfect crunches compared to an athlete who can only do 1,000? However, is core strength even a prerequisite to high performance? Maybe we should ask Babe Ruth.

Core training has become a fixture in performance and fitness programming. First popularized in the 1980s by the San Francisco Spine Institute (3), core training has evolved to be a cure-all for all manners of performance and health deficits. Reports have been made that core training has had a positive performance impact on just about anything that can be associated with activity or sports, from a golfer's club head speed to 40-yard dash times. These claims (not all unfounded) have spurred a lot of interest in core training and even more in core training gadgets. Core training has been adopted by a very diverse population of users ranging from elite athletes to out-of-shape and overweight couch potatoes (3). Ironically, much of the "evidence" used to promote core training was performed on a non-athletic population (7). This can be a serious threat to external validity. Much of what is being touted as benefits of core training has not been validated for elite athletes. One should not assume that core training with a stability ball will have the same, or even similar, outcome for an elite athlete as it would on a part-time recreational one. For example, Stanton et al. (5) did not find a greater or more significant improvement in running economy or running posture of a stability ball-trained group over that of the control group. Furthermore, core stability has yet to be directly correlated with higher performance. That is to say, no one knows for sure if there is a linear correlation with improved core strength to sports performance (or even more relevant if core strength is correlated to more "W's" in the win column). Several studies have been conducted that have not shown a significant difference in performance as a result of core training as compared to other forms and types of training in competitive athletes (7). However, core training does appear to contribute to improvements in performance measures of sedentary or recreational athletes (1,2,6,8) and has been shown to increase lactate clearance following intense exercise in a mixed population (4).

In hindsight, these findings (and others like them) should be expected. Non-elite, or recreational athletes, have historically responded better to any training intervention, given that they are further away from the performance ideal. Well-trained athletes are very near, or even often transcend that ideal and therefore have less of a margin for improvement. This phenomenon seems to be the case with core training as well. The cursory review of the evidence seems to be that core training does not have as dramatic an impact on the trained athlete's performance when compared to recreational athlete's improvements, as a result of core training.

None of this is to say that core training is not valuable. On the contrary, it is, as I already stated, "integral to responsible training." However, it is important to ask, "how are we measuring core training and what standards are we using?" If the only benefits (or most significant benefits) are primarily shown in sedentary populations, are we even asking the right questions? Furthermore, are the performance measurements we use to justify core training correlated to measures of sports success (i.e., greater salaries, longer contracts, less injuries, more wins, more scholarship offers, etc.)? Food for thought.

When critiquing the evidence, it is important to operationally define and differentiate core training from its close relatives. In essence, core training focuses on the muscles of the core (Table 1) and can be isolated or trained as groups; as opposed to functional training, which tends to focus on movement and movement patterns, regardless of the specific muscles involved. That being said, it is still difficult to differentiate core and function.

Core training has taken on many forms throughout its evolution. Just about any activity that utilizes core muscles in isolation, or in groups, can be considered core training (although it is certainly more "functional" to create ways to use them in groups). Equally as diverse is the equipment used for core training which includes medicine balls, kettlebells, stability balls, balance boards, wobble boards, dumbbells, or no equipment at all—this is by no means an exhaustive list. Core training can also be performed in any number of positions, from inverted hanging to prone quadruped. In essence core training is only limited to the imagination of the fitness professional designing the program. Basically, anything that calls for the simultaneous or sequential activation of core muscles, preferably at sport-specific velocities, can be core training, even it if does not come close to replicating a specific sport's typical movement patterns.

When it is all said and done, it is important to ask the right questions and to responsibly critique the evidence and substantiate claims being made without stifling creativity. Patients, clients and athletes require greater core strength for a variety of different reasons. Those reasons include rehabilitation for daily functions (i.e., ADL's), rehabilitation for return to competitive sports, fitness training for balance and posture, strength training for competitive advantage, and needing something to do during a cool down. Whatever the reason, it is important to ask the right questions for why we are doing something.

When beginning a core training program, I recommend considering the following questions:

- How much core strength is enough?
- What is the most efficient (and safest) way to integrate core strength and function?
- How will these exercises promote the goal of the participant?
- Are new or experimental core exercises warranted? (if so why)
- Is the goal to reach a predetermined standard of participation or function (i.e., in rehabilitation, reconditioning, for proper ADL's) or is it to gain a competitive advantage?
- What is the outcome that is hoped for and how will I measure it?

Core training can be adapted to meet the needs of all these individuals but it is important to evaluate the evidence before wholesale adaptation. The reality is core strength (and not core "training") is a significant contributor to function, coordination, balance, and injury prevention. The best way to achieve core strength will vary between the population as well as the reasons for needing core strength. ■

Table 1.

Common Core Muscles	Action
Rectus Abdominis	Flexes the spine (lumbar vertebrae)
Transversus abdominis	Compress the ribs and viscera, providing thoracic and pelvic stability
Quadratus lumborum	Unilateral: lateral flexion of vertebral column; Bilateral: depression of thoracic rib cage
Gluteus maximus	Powerful extensor of hip; laterally rotates thigh; upper fibers aid in abduction of thigh; fibers of IT band stabilize at knee extension
Gluteus medius	Anterior and lateral fibers abduct and medially rotate the thigh; posterior fibers laterally rotate thigh; stabilizes the pelvis and prevents free limb from sagging during gait
Illiopsoas	powerful hip flexion; lateral rotation
Erector Spinae group	Bilateral: extension of vertebral column; maintenance of erect posture; stabilization of vertebral column during flexion, acting in contrast to abdominal muscles and the action of gravity. Unilateral: lateral bend to same side; rotation to same side; opposite muscles contract eccentrically for stabilization
Multifidus	Bilateral: extends vertebral column; controls lateral flexion to side opposite contraction (eccentric for stability); Unilateral: rotates vertebral column to opposite side
Piriformis	Lateral rotation of extended thigh; abducts a flexed thigh
Tensor fascia lata	Hip flexion; medially rotate and abduct a flexed thigh; tenses IT band to support femur on the tibia during standing
Rectus femoris	Extends knee; flexes hip
Pectineus	Flexes hip; adducts thigh; medially rotates thigh
Sartorius	Flexes hip and knee; laterally rotates thigh when flexed at the hip

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