Core Stability

for Performance and Injury Prevention

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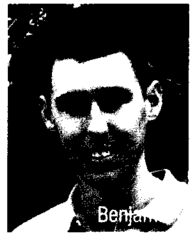

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What is core stability?

Core stability is a term that has endured a meteoric rise in popularity over the past two decades. While its origin seems rooted in the research domain of clinical biomechanics, many sports, fitness and health-related professionals have willingly adopted it. Clinicians, sports scientists, strength and conditioning coaches, personal trainers, athletic coaches and athletes use the term on an almost daily basis, yet it is commonly used interchangeably with terms such as core strength, core muscle training and lumbar stabilization. Such varied nomenclature has created confusion and caused considerable resistance in achieving a universal definition.

One of the difficulties in defining core stability appears to stem from the word core. Core is a somewhat nebulous term, which formally refers to 'the central or innermost part of a particular entity or object' (Merriam-Webster 2003). With reference to the athlete, the core is typically referred to as any musculoskeletal structure that is encompassed by the abdominal and lumbar spine regions (Leetun, Ireland et al. 2004; Kibler, Press et al. 2006). This fairly loose description, has led to a variety of structures and more specifically muscles, being classified as part of the core. The most commonly implicated muscles include the transversus abdominis, internal and external obliques, rectus abdominis, quadratus lumborum, multifidus, gluteus medius (lateral) and maximus, pelvic floor muscles, and the diaphragm (Akuthota and Nadler 2004; Fredericson and Moore 2005; Kibler, Press et al. 2006; Hibbs, Thompson et al. 2008).

A brief history of core stability

The word stability has also created some debate amongst professionals, though perhaps not to the extent of the term core. Core stability arguably developed from the work of Manohar Panjabi (1992). Panjabi, a mechanical engineer and biomechanist from Yale University, was one of the first researchers to systematically analyse spinal biomechanics using cadaveric specimens. The overall premise of his work was that spinal stability (ie of the lumbar spine) was the result of an interaction between the spine's passive elements (eg joints, ligaments), active elements (eg muscles and tendon acting on the lumbar spine), and neural elements (eg nervous system control of spinal muscles) (Panjabi 1992). Panjabi's experiments involved the application of axial loads of varying magnitudes to cadaveric spines, which led to buckling at critical thresholds. This experimental data was subsequently used to run computer simulations, which revealed that stiffer spinal columns were more resistant to the buckling effect, and therefore were considered more stable (Panjabi 2003). Given the low loads required to cause buckling in the cadaveric specimens, it was suggested that in living human subjects, active contraction of the spinal musculature was necessary to maintain stability and allow for normal everyday functioning. Although Panjabi referred to his early work as spinal stability, over time, others have used this idea and findings to support not only the term, but also the concept of core stability.

Many current day definitions refer to core stability as a type of dynamic equilibrium between whole body movement and controlled motion or stability of the spine. This is markedly different from Panjabi's early concept of spinal stability. The definition offered by Kibler and colleagues (2006), for example, defines core stability as 'the ability to control the position and motion of the trunk over the pelvis and leg to allow optimum production, transfer and control of force and motion to the terminal segment in integrated kinetic chain activities' (Kibler, Press et al. 2006). Similarly, Bliss and Teeple's (2005) definition refers to core stability as 'the ability to use muscular strength and endurance to control the spine beyond the neutral zone when performing functional and athletic activities'. While there are similarities between these and other more recent definitions of core stability, a lack of consensus continues to create misunderstanding amongst researchers, clinicians, coaches and athletes alike. We recommend that more specific, anatomically and biomechanically relevant terminology be used. Rather than core stability, we propose a more descriptive term such as lumbopelvic motor control. Nonetheless, for simplicity, and in keeping with the term used by most of our cited reports, we will persist with the term core stability for the remainder of this article.

Measuring core stability

The lack of a common definition also means that assessing or measuring core stability is a difficult task. A multitude of tests have been proposed by researchers and clinicians as valid and reliable measures of core stability (Liemohn, Baumgartner et al. 2005; Marshall and Murphy 2005; Kibler, Press et al. 2006; Okada, Huxel et al. 2011), however typically there is little empirical evidence to support such claims. In fact, one study reportedly examined the reliability of 35 core stability related tests (Andy Waldhelm 2012). Careful review of the actual tests examined, revealed that many of the tests were not true tests of core stability and would be more appropriately classified as tests of lower limb strength or flexibility (eg isometric hip extension strength and hip internal/external range of motion).

While it is doubtful that there is one true test for core stability, further discussion and consensus about the most valid core stability tests is required. We would suggest that the most useful tests are likely to focus on lumbopelvic motor control during whole body dynamic tasks (Leetun, Ireland et al. 2004; Kibler, Press et al. 2006). Such tasks not only require controlled and coordinated movement, but other physical attributes such as strength, endurance, balance and proprioception. Therefore, individuals examining core stability should carefully select a range of tests that require good lumbopelvic motor control in the context of the relevant athletic activity.

Core stability and performance

A key component of almost all high performance athletic training programs is core strength or core stability training (Akuthota and Nadler 2004; Hibbs, Thompson et al. 2008). If one is to question a coach or athlete why core exercises are included in a training program, the response invariably includes some reference to an improvement or enhancement in athletic performance. Interestingly though, there is only a modicum of evidence to suggest that core training does indeed improve athletic performance in trained athletes.

A vital feature of all training programs including core stability training is the specificity of that program to the athlete's particular sport or athletic task. There are numerous examples in the literature of core stability training improving measures of core performance without corresponding improvements in athletic performance (Willardson 2007). Schibek and colleagues (2001) for example, compared the effect of a Swiss ball training program (ie core stability) on swimming performance in elite level swimmers. While the core stability group demonstrated improvements in core stability measures, there was no benefit to swimming performance times. Similarly, in a study by Stanton and colleagues (2004), the effect of a six-week core stability training program on running economy was examined in a group of high school athletes. Of the performance measures tested, no improvement in maximal oxygen uptake, running economy, or running posture was observed. Likewise, Tse and colleagues (2005) found a similar result in their investigation of experienced rowers, who undertook a core endurance training program over an eight- week period. Functional performance measures such as vertical jump height, shuttle run time and medicine ball throw distance all improved, however, no observable improvements in rowing performance resulted.

Using a slightly different approach, Nesser and colleagues (2008) examined the relationship between various core stability measures and a number of strength and power variables in football players. The football players were specifically selected due to their focus on strength and power training under normal training conditions. Results demonstrated only weak to moderate correlations between measures of core stability and strength and power variables, indicating that improvements in core stability are unlikely to result in changes in strength and power. While this might seem intuitive, it does illustrate the importance of ensuring training programs are as specific as possible to the precise athletic tasks to be undertaken.

One particular investigation that did demonstrate a positive effect of core stability training was that of Saeterbakken and colleagues (2011), who investigated a core training regime in a group of female high school handball players. Following a six-week training program, the core stability group demonstrated a significant improvement in throwing velocity compared to the control group. While the authors theorized that an improvement in core stability might have contributed to the improvement in throwing velocity, it is possible that the improvements were due to a general improvement in strength and power. The addition of a second experimental group to participate in strength-based training would help to clarify this issue.

Core stability and injury

With the wave of enthusiasm over core stability, many coaches and their athletes are including core exercises in conditioning programs not only for the purpose of improving performance, but with the intention of reducing the likelihood of injury. Whilst there is some evidence that improved core stability or improved control over lumbopelvic motion may be associated with reduced injury risk, very little robust data from controlled or prospective studies is available. Much stronger factors, such as fatigue and overtraining tend to drive injury risk (Lederman 2010).

One argument that has been used to demonstrate associations between core stability and injury relates to gender differences in physical measures such as abdominal muscle activation or movement patterns of the pelvis. Some suggest that the higher rate of lower limb injury seen in women compared to men is a result of the relatively weaker muscles and poorer movement patterns leading to greater demands placed on female lumbopelvic muscles than those of men (Ferber, Davis et al. 2003). Prospective data, however, is not available to support this theory.

Given that poor endurance of core muscles, such as erector spinae and multifidus has been associated with low back pain, some have advocated the incorporation of endurancefocused exercises that train such muscles at low loads with progressively increasing contraction durations (McGill 2001). Once again, supporting data is merely correlational. Exercises performed on unstable surfaces or equipment (e.g. mini-tramps and balance/wobble boards) have also been suggested as a means to improve 'core stability' in an effort to prevent injury, particularly in prevention of anterior cruciate ligament injuries (Caraffa, Cerulli et al. 1996). Outcomes from this type of training approach are more likely to reflect neuromuscular adaptations (e.g. improved movement patterns, reactions, and readiness) more than changes in core strength or core stability. Certainly, the position and motion of the trunk and pelvis are implicated in undesirable lower limb movement patterns associated with lower limb injury in sports involving landing and cutting manoeuvres (Hewett and Myer 2011). Weak hip muscles, for instance, are associated with knee injuries (Leetun, Ireland et al. 2004). If direct effects of core stability training on injury risk are possible, then specificity of adopted exercises to the sport or athletic event is likely to be a key factor for success (Willardson 2007).

Until more convincing data is available, including core stability training for the purpose of injury prevention is unsupported. In fact, a recent critical review concluded that 'core stability exercises are no more effective than, and will not prevent injury more than, any other form of exercise or physical therapy' (Lederman 2010). Consultation with appropriate health professionals and inclusion of sport-specific injury screening by such professionals to develop targeted exercise programs is likely to be a more fruitful approach to minimising injury risk.

Practical recommendations for coaches

When developing training programs for athletes, coaches should carefully consider the physical requirements of the particular task or event. Rather than simply prescribing generic core stability exercises in the hope of improving performance, coaches should adopt exercises that are as specific as possible to the actual task. If the athlete is a sprinter, for example, the focus should be on strength and power based activities that involve primarily single leg activities. A power based hopping or lunging activity, for example, where the athlete is focussed on maintaining good pelvis and trunk control (Figure 1 on Page 16) is likely to be more beneficial than a Swiss ball exercise where the athlete is trying to balance on one leg while maintaining pelvis and trunk control (Figure 2 on page 16). Similarly, if an athlete is competing in throwing events involving dynamic whole body movement, an upper body, power based throwing exercise (Figure 3 on page 16) is likely to be of more benefit than a core exercise involving trunk stabilising or balancing on a Swiss ball.

Conclusion

In our opinion, the term, and more importantly the concept 'core stability' be reconsidered. We propose that clinicians, coaches and trainers use a clearer, more specific description such as lumbopelvic control. Furthermore, we have demonstrated that there is little empirical evidence to support core stability training for performance enhancement or injury prevention. While core stability training will be of value to some, universal prescription to every athlete is not justified. Rather, coaches and athletes should implement exercise programs that are individualised, based on musculoskeletal screening, and with deliberate specificity to the athletic task.

Key Points

- Core stability is a nebulous term and so a more descriptive term such as lumbopelvic control is recommended
- Core stability training may successfully improve measures of core stability, but not necessarily athletic performance
- There is little evidence to suggest that core stability training alone will prevent injury

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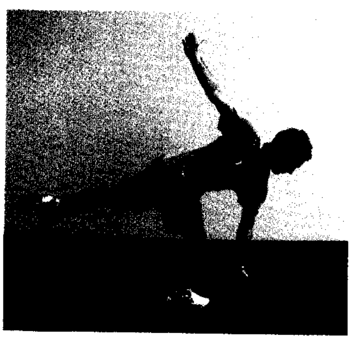

Figure 1

Figure 2

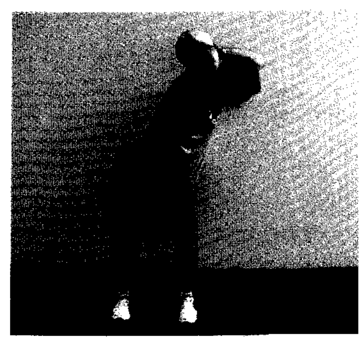

Figure 3