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Effects of Core-Stability Training on Performance and Injuries in Competitive Athletes

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Most competitive athletes perform core-stability training to some extent. In the slideshow accompanying this article we provide a critical overview of scientific studies exploring the relationship between core stability and athletic performance, injury prevention and injury rehabilitation. We also identify methodological limitations and concerns associated with these investigations and provide recommendations for training and rehabilitation. The field suffers from the lack of terminological consensus, and the varying definitions of *core* can make for confusion as they involve diverse anatomy (e.g., with or without limbs). It is also problematic that parts of the theoretical framework related to core stability have emerged from studies of low back pain, questioning the relevance to athletes. Numerous tests have been proposed to assess core stability, but no universal standards have so far been developed. The proposed core stability tests either have poor validity and reliability or have not been assessed for validity and reliability at all. Targeted core-stability training interventions have in some cases provided positive effects on sport-specific tasks (e.g., throwing velocity). A few cross-sectional studies have reported small-to-moderate relationships among core stability and some sport-specific tasks with strong core components (e.g., baseball pitching/batting, golf, tennis serve). However, a causal relationship between core stability and athletic performance has not been established, owing to limitations in previous study designs. Moreover, poor core stability in isolation is not a predominant risk factor for athletic injuries. Stabilization training of the core may enhance the recovery time for certain injuries, but no better than any other training forms in the long term. In conclusion, isolated core stability training should not be the primary emphasis for programs with the goal of enhancing athletic performance, preventing injuries or reducing injury recovery time. More research in the field is needed for operational definition purposes, developing valid and reliable core stability tests, and exploring cause-effect relationships among core stability and athletic performance, injury prevention and rehabilitation. KEYWORDS: lumbo-pelvic stability, rehabilitation, stabilization.

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References (in RefMan/RIS format)

More than a decade ago, several authors proposed that core stability was essential for athletic performance and injury prevention (Hodges and Richardson, 1996; Hodges and Richardson, 1998; Kibler et al., 2006). Their theories were based mainly on studies dealing with low back pain patients. The arguments and recommendations from these studies were promptly accepted and adopted by the fitness industry (Willardson, 2007). The early studies have been cited frequently, as they provide a point of departure for further investigations within the topic, and the importance of core stability on athletic performance and injury prevention has been heavily debated the last decade. Definitions of the term *core stability* vary across studies according to the context in which they are viewed. However, most authors generally incorporate the trunk into the core definition, with special emphasis on the lumbo-pelvic region of the body (Willardson, 2007). The stabilizing system consists of passive (ligaments and

bones), active (muscles) and neural structures (Panjabi, 1992).

Do competitive, high-level athletes perform core training? If we look to scientific publications, the general training patterns of world-class performers in a broad range of sport disciplines have been described, including ice hockey (Ebben et al., 2004), rowing (Fiskerstrand and Seiler, 2004), cross-country skiing (Sandbakk and Holmberg, 2014; Tonnessen et al., 2014), biathlon (Tonnessen et al., 2014), speed skating (Orie et al., 2014), soccer (Malone et al., 2015), orienteering (Tonnessen et al., 2015b) and Nordic Combined (Tonnessen et al., 2015a). Unfortunately, these studies do not reveal to what extent core training has been performed, as core training was not quantified.

As conditioning experts and physiotherapists at the Norwegian Olympic Training Centre, the present authors have in-depth knowledge of daily training and rehabilitation programs for a large number of high-level performers. Our inspection of training sessions, training diaries and conversations with athletes and coaches) reveals that core training is performed by world-class athletes in cross-country skiing, biathlon, ski jumping, Nordic combined, speed skating, snowboard, alpine skiing, ice hockey, soccer, handball, rowing, kayak, swimming, cycling, golf, sailing, taekwondo, wrestling, orienteering and athletics. Indeed, core training is one of very few training forms common for all these sport disciplines. The total weekly core training volume varies considerably among individuals and sport disciplines, ranging from 5 min to 2 h per week. Anecdotally, cross-country skiers, rowers, kayakers, sailors and golfers typically perform more core training than other athlete groups. However, a common trend among most individuals is higher core training volume during preparation periods compared to competition periods. Moreover, core training is performed more during injury rehabilitation periods, when sport-specific training is prohibited.

High prevalence of low back pain during a season has been reported in athlete populations such as cross-country skiing (Alricsson and Werner, 2005; Alricsson and Werner, 2006; Bahr et al., 2004; Foss et al., 2012), rowing (Bahr et al., 2004; Foss et al., 2012), orienteering (Bahr et al., 2004; Foss et al., 2012), gymnastics and rhythmic gymnastics (Purcell and Micheli, 2009). Competitive young cross-country skiers relieved back pain by changing body position during exercise (Alricsson and Werner, 2005), emphasizing the importance of preventive strategies such as core training to reduce back pain. Core stability training is often used in athletic populations for back-pain treatment (Puentedura and Louw, 2012). Pain affects motor control (Hodges and Moseley, 2003), and some therefore argue that clinicians' management of athletes with low-back pain should include training and biopsychosocial approaches (Puentedura and Louw, 2012).

Although core training is not the main training form for any sport discipline, the majority of competitive athletes perform such training to some extent. In addition, even though the core is a popular target for athletic conditioning in general, questions remain regarding training effects, overall performance benefits, injury prevention and rehabilitation from injury. Therefore, we had three objectives in preparing a tutorial presentation on core training: to provide a critical overview of scientific studies exploring the relationship between core stability and athletic performance, injury prevention, and injury rehabilitation; to identify methodological limitations and concerns associated with these investigations; and to provide specific recommendations for core training and rehabilitation.

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