This is the second of a two-part report on core stability. Part 1 defined the terms core and core stability and provided an overview of changes that occur in core muscles as a result of low back dysfunction. These changes negatively affect core stability, creating a risk for future injury to the low back and/or lower extremity. Core stability is essential for the development, transfer, and dissipation of forces throughout the kinetic chain, both from the core to the extremities and from the extremities to the core. The core-extremity relationship has been described as “proximal stability for distal mobility of the limbs.” The transfer of energy from the core to the extremities is analogous to the cracking of a whip. This transfer of forces requires adequate muscular capacity (strength and endurance) and central nervous system motor programming that produces synchronous activation of the muscles. The objectives for Part 2 are to describe the core-extremity link and to suggest strategies for improvement of core stability and integrated lower extremity function.

**The Role of Muscle Endurance**

Poor endurance of the core muscles negatively affects function throughout the kinetic chain. In both healthy individuals and patients with low back pain, fatigue of the paraspinal muscles has been shown to result in altered standing postural control, a forward-leaning posture, a reduction in trunk proprioception, and a decrease in neural activation of the quadriceps. Trunk displacements resulting from impaired neuromuscular control produce sudden shifts in the location of the center of mass over the base of support. Maintenance of postural stability requires the generation of internal muscle moments to counteract the external moments generated by body mass displacement. A fatigued muscle may be incapable of effectively counteracting external moments, which may increase risk for injury if joint displacement is excessive, especially in the presence of quadriceps inhibition and altered trunk proprioception.

Back muscle fatigue that results in forward body lean is a concern, because fatigue has been shown to produce earlier activation and longer duration of the flexion-relaxation response (i.e., myoelectrical silence of the erector spinae muscles when in a flexed trunk posture). Although other back muscles, such as the quadratus lumborum, may still be active, the reduced activity of the erector spinae muscle group places greater load on passive stabilizers. Furthermore, a forward leaned posture shifts the center of mass anteriorly, resulting in alteration of the external moments acting on joints throughout the lower extremity.

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**Key Points**

- There appears to be a relationship between core muscle function and extremity injury risk.
- Fatigue of the core muscles affects lower extremity function.
- Although some core stabilization programs have demonstrated effectiveness, not all individuals derive benefit from core stability exercises.
ultimately place greater demand on the quadriceps muscles. Decreased activity of the quadriceps muscles (i.e., quadriceps inhibition) that occurs following back muscle fatigue may lead to poor attenuation of ground reaction forces (GRFs). Consequently, excessive forces may be transmitted through the knee, hip, and lumbar spine joints. There is also evidence suggesting that the hamstring muscles exhibit an adaptive response to compensate for reduced quadriceps and gluteus maximus activity, thereby exposing the hamstrings to elevated injury risk.9

There is growing evidence that poor core endurance can also lead to potentially injurious lower extremity positions in the frontal and transverse planes. Inadequacy of the hip abductor mechanism to control pelvic-femoral alignment has been related to lower extremity dysfunction. Fatigue, weakness, and imbalances in hip and pelvis muscles may result in hip adduction and internal rotation (Figure 1). This knee-valgus position has been associated with patella-femoral syndrome and noncontact ACL injuries, which has been identified as a particular concern in female athletes. Lower extremity malalignment (trunk flexion, anterior pelvic tilt, hip adduction, hip internal rotation, knee valgus, and foot pronation) has been extensively discussed in the literature as predisposing factor for development of lower extremity pathology. These findings clearly indicate a need for comprehensive assessment and a rehabilitation strategy for management of back conditions.

Perception of Fatigue
Interestingly, the perception of fatigue may not necessarily indicate the existence of an actual fatigued state of the muscles. Comparison of two fatigue protocols (rowing ergometer versus exercises targeting the paraspinal muscles) revealed that muscle activation times were increased following the muscle-specific fatigue protocol, but perception of fatigue was greater following the rowing ergometer protocol. Fatigue of the multifidus muscle initiates a chain of events that may result in the inability to effectively counteract external moments. This is a particular concern during sudden and unpredictable loading, which is a common mechanism of back injury. Fatigue alters neuromuscular control (altered afferent input to the central nervous system, inhibition of motoneurons that activate the multifidus muscles, and reduced muscle spindle-generated reflex response), which may alter the loads on the spine and leave the structures of the spine more susceptible to injury. Consequentially, an individual may continue activity while fatigued, thereby exposing the back and extremities to abnormal loading and possible injury.

Measurement of Core Endurance
Strength, endurance, and flexibility are considered to be important components of fitness. Endurance is frequently ignored in back assessments, despite the fact that poor muscle endurance appears to be more strongly related to low back dysfunction than weakness or range of motion deficits. Core endurance testing has demonstrated utility for assessment of low back dysfunction and also for identification of individuals who possess elevated risk for back and lower extremity injury. Tests such as the trunk flexion hold, wall sit hold (unilateral), and horizontal trunk hold (Figure 2),