Low back pain and risk of lower extremity injury

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By Ram Haddas, PhD

Low back pain is associated with kinematic and kinetic alterations that can increase the risk of lower extremity injury, particularly in the presence of fatigue. New research suggests neuromuscular training programs can be designed to help reduce injury risk in patients with low back pain.

Lower extremity injuries and low back pain (LBP) pervade everyday life. Injuries are often associated with physical, emotional, and economic costs, including loss of work time, and quality of life.[1] Hamstring muscle strains, anterior cruciate ligament (ACL) injury, and ankle sprain are the most common sports injuries.[2,3] Low back pain can also significantly influence an individual's quality of life; estimates of the incidence of LBP in athletes vary depending on the sport, but range from 10% up to 80%.[4] Despite apparent advances in the diagnosis and management of LBP, this disorder is a large burden on individuals and society.[5] Additionally, LBP can alter functional ability and increase the risk of lower extremity injury.[6-8]

Failure of the abdominal and lumbar musculature to provide adequate support to the lumbar spine during loaded positions and movements is considered a contributing factor to the persistence of LBP and dysfunction.[8-10] Individuals with LBP demonstrate impaired postural control, delayed muscle reflex latencies, and abnormalities in trunk muscle recruitment patterns.[7-12]

Low back pain and injury risk

Trunk muscle function is altered in LBP sufferers.[7-8] As a result, these individuals may not be able to produce sufficient pelvic stability to provide a stable base for lower extremity motion and control. Proximal alterations in the operation of this kinetic chain linkage may increase injury risk at more distal regions. This relationship between LBP and altered lower extremity movement control has been observed in several studies.[6,8-10]

Modifications to equipment, training, or preparation may be warranted for women with low back pain, and for both genders under fatigued conditions

Zazulak et al,[6] for example, found that a history of LBP, along with trunk displacements and proprioception, were significant predictors of overall knee injury in female athletes and knee ligament injury in male athletes. Individuals with LBP demonstrated impaired postural control, delayed muscle reflex latencies, and abnormalities in trunk muscle recruitment patterns. Additionally, decreased neuromuscular control of the spine appears to influence dynamic stabilization of the knee joint and increase lower extremity injury risk. Low back pain was a significant predictor of knee injury and impaired lower extremity control. Patients with low back pain have diminished lower extremity strength, flexibility, and range of motion,[9] as well as altered lower extremity biomechanics and neuromuscular control.[11] These changes may increase lower extremity injury risk.

Prospective clinical studies have linked LBP history with lower extremity injuries, and a history of lower extremity injury with LBP. Zazulak and colleagues[6] found that a history of low back pain was a significant predictor of knee injury in both female athletes and knee ligament injury in male athletes. Nadler and colleagues[12] observed that athletes with a history of lower extremity overuse or ligamentous injury were significantly more likely to be treated for LBP during the following year.

Fatigue is also a major risk for injury that alters muscle shock-absorbing capacity and coordination of the locomotor system, observed by decreased lower extremity muscular maximum voluntary contraction strength, ground reaction force (GRF), and initial impulse and increased quadriceps latency stretch reflex activity and knee flexion at contact.[13] Fatigue can affect neuromuscular input pathways, commonly observed as proprioceptive alterations,[14] as well as neuromuscular output pathways, as evidenced through a delay in muscle response. Fatigue may reduce maximum voluntary muscle force and work capacity, altered movement control, and delayed muscle reaction time during the performance of dynamic maneuvers.[15] Muscle fatigue has been linked to a variety of lower extremity injuries.[16]

Our research

Three studies[8,10,17] conducted by the author and colleagues in the past year at Texas Tech University Health Sciences Center in Lubbock examined the effect of fatigue on biomechanics in individuals with LBP and how those effects are modified by core muscle activation, gender, and movement task.

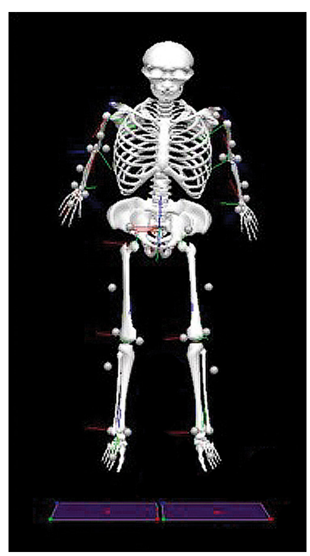

Figure 1. Motion analysis animation shows the airborne phase of landing.

The purpose of the first study[10] was to test the hypothesis that core muscle activation would modulate the effects of lower extremity fatigue on lower extremity and trunk mechanics, as well as neuromuscular control during landing, in people with and without recurrent LBP. Thirty-three healthy individuals (age = 20.94 ± 2.27 years, height = 1.69 ± 9.62 m, mass = 71.18 ± 14.50 kg) and 32 with LBP (age = 21.16 ± 2.77 years, height = 1.69 ± 13.02 m, mass = 74.47 ± 14.22 kg) performed a series of 12 double-leg landing trials. They did six trials with and without core muscle activation activity (three each) in random order. The fatigue protocol included dynamic squatting in a squat machine with 15% of body weight until task failure, defined as altered squat performance (ie, increased forward trunk lean or altered forward knee position relative to the ankle) or inability or unwillingness to continue. After the fatigue protocol, participants performed another series of six landing trials, three each with and without core muscle activation, in a random order.

This study's findings demonstrated that core muscle activation and fatigue were associated with altered landing mechanics in healthy and LBP groups and that there were differences between groups. Semitendinosus onset exhibited a significant three-way interaction between groups, core muscle activation, and fatigue conditions.

The results of this study suggest core muscle activation appears to create a protective advantage for the knee and lumbar spine. Earlier semitendinosus activation, which occurred during the core muscle activation conditions for the .30-m drop vertical jump landing, could potentially help to prevent injury if a perturbation is encountered during a landing task.[18] In addition, these changes suggest that core muscle activation prior to initial ground contact may enable the neuromuscular system to better prepare for encountering stresses imposed by the landing sequence. Core muscle activation was also associated with significantly decreased lumbar kinematic angles, suggesting that core muscle activation helps sustain the natural lumbar curve in both groups during the landing task.

In summary, this study's results provide evidence that a core muscle activation strategy performed during a fatigued landing sequence decreases exposure to biomechanical factors (ie, spinal instability, latency in muscle recruitment) that can contribute to lower extremity injury, particularly ACL injury. This apparent protective response was observed when both healthy individuals and those with LBP land from a .30-m height. Incorporating core muscle activation during dynamic stressful activities, with and without the presence of fatigue, appears to improve sensorimotor control and facilitate positioning of the lower extremity, while also protecting the lumbar spine. Clinicians can use this information when designing neuromuscular control training programs for people who have recurrent LBP to improve lower extremity control, spine stability, and response to a fatiguing activity, thus potentially decreasing injury risk.

The role of gender

The purpose of the second study[8] was to determine the effects of lower extremity fatigue and gender on knee mechanics, neuromuscular control, and GRF during landing in people with recurrent LBP. It used the same landing and fatigue protocols as the previous study[10] and included 15 women (age = 20.60 ± 1.85 years, height = 1.62 ± .14 m, mass = 65.47 ± 12.41 kg) and 17 men (age = 21.65 ± 2.30 years, height = 1.75 ± .80 m, mass = 82.42 ± 10.48 kg).

The study found the biomechanical responses were generally similar to those reported in previous landing studies of populations without LBP.[19-20] When performing .30-m landings, women with recurrent

LBP landed differently than their male counterparts. Women tended to have a greater knee flexion angle at initial contact but no difference in maximum knee flexion angle compared with men, which indicates less knee flexion range of motion than men during the eccentric landing phase. However, GRF impact was lower in women than in men, and maximum GRF was not different between genders; therefore, it is unlikely that the reduced knee flexion in women resulted in an overall stiffening of the lower extremity. Instead, the women may have utilized a landing strategy that relied on joints other than the knee to absorb landing energy. Additionally, women with recurrent LBP tended to have a greater maximum knee internal rotation angle during the landing phase compared with men, a finding that agrees with published studies that have examined landing in women without LBP.[19-20] Excessive knee internal rotation has been associated with increased ACL injury risk.[21]

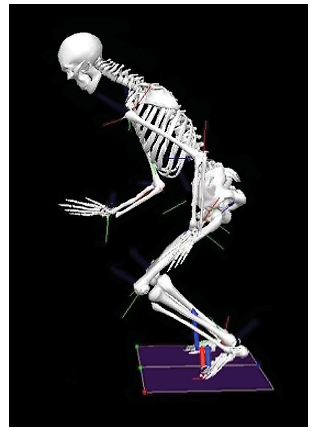

Figure 2. Motion analysis animation shows the end of the eccentric phase of landing.

Women with recurrent LBP exhibited a greater maximum knee flexion moment than men, who had an extension moment. This might be explained by previous research showing that women land with a more erect trunk posture than men,[22] although trunk position was not examined in our investigation. Women with recurrent LBP tended to have smaller knee adduction and ankle inversion moments than men with recurrent LBP, which could indicate different hip-knee-ankle alignments and an increased risk of ACL injury.[23]

In addition to impaired postural control, delayed muscle reflex latencies, and abnormalities in trunk muscle recruitment patterns, decreased neuromuscular control of the spine appears to influence dynamic stabilization of the knee joint and increase lower extremity injury risk, a finding observed mainly in women.

The third study[17] was designed to determine the effects of lower extremity fatigue and gender on knee and trunk mechanics, GRFs, and knee moments during unexpected landing and cutting in people with recurrent LBP. It included 16 women (age = 20.87 ± 2.61 years, height = 1.70 ± .05 m, mass = 64.31 ± 9.89 kg) and 16 men (age = 22.31 ± 1.89 years, height = 1.81 ± .09 m, mass = 82.57 ± 9.08 kg). The fatigue protocol was the same as in the two previous studies, but the landing protocol differed slightly. The landing trial was started when the participant stepped forward with the right foot and dropped down from a box, landing with each foot on a separate force platform simultaneously, and then immediately either performing a maximum vertical jump or cutting 45° to the left, pushing with the right leg. An electronic board was used to instruct participants to either cut or jump when landing. A pressure sensor on the .30-m box allowed the directional command to be relayed only once the participant was airborne, providing an element of surprise.

The study results showed fatigue altered landing mechanics, with differences between genders for landing and cutting performance. When landing before a jump, women had smaller maximum knee flexion angles, greater knee adduction angles at maximum knee flexion, greater knee external rotation angles at maximum knee flexion and at initial contact, greater trunk flexion angles at maximum knee flexion, and smaller maximum knee flexion moments. Furthermore, during the cutting task, women had greater knee adduction angles at maximum knee flexion, greater knee external rotation angles at maximum knee flexion and at initial contact, greater trunk flexion angles at maximum knee flexion, and smaller trunk side flexion angles at maximum knee flexion. Fatigue resulted in smaller trunk flexion angles at initial contact for the jumping task, and greater trunk extension and trunk side flexion angle at maximum knee flexion, smaller maximum vertical GRF on the right leg, and maximum knee adduction moment when cutting 45° to the left.

The results of the last two studies provide evidence for gender and fatigue differences in landing and cutting mechanics and neuromuscular control in individuals with LBP. The majority of the gender- and fatigue-related differences are consistent with results from similar studies of individuals without a history of LBP.[6-11] Fatigue is associated with altered landing and cutting mechanics, changes that are consistent with an increased risk of ACL injury. Women who suffer from recurrent LBP also demonstrate biomechanics during landing from a .30-m height and 45° cutting that may result in a higher risk of ACL injury than in men with recurrent LBP.

Conclusion

Accurate identification of potentially risky movement behaviors is important for appropriate conditioning, treatment, and rehabilitation. Our results should be considered and may serve as a guide for modifications to equipment, training, or preparation practices for women with recurrent LBP, and for both genders during fatigued landing events. In particular, clinicians can use this information when designing neuromuscular control training programs for female athletes with recurrent LBP to potentially reduce the incidence of biomechanical factors associated with lower extremity injury risk.

Ram Haddas, PhD, is director of research at Texas Back Institute Research Foundation in Plano.

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