Ankle Flexibility and Jump Landing Mechanics: Implications for ACL Injury Risk

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Source

Fong CM, Blackburn JT, Norcross MF, McGrath M, Padua DA. Ankle-dorsiflexion range of motion and landing biomechanics. *J Athl Train.* 2011;46:5-10.

The anterior cruciate ligament (ACL) is one of the primary ligaments that provides knee joint stability. Injury to the ACL can occur as a result of participation in sport, with as many as 80% from a noncontact mechanism.[1] Female athletes have been found to have an ACL injury incidence that is substantially greater than that of males.[2] ACL injury typically requires surgical reconstruction and extensive postsurgical rehabilitation and imposes a significant delay in return to sport participation. Furthermore, ACL injury increases risk for development of knee osteoarthritis.[3]

Key Points

- Amplitude of passive ankle dorsiflexion is associated with amount of knee flexion during jump landing.
- Reduced peak ground reaction force during jump landing was associated with increased ankle dorsiflexion.
- Ankle dorsiflexion ROM exercise with knee extension should be considered for athletes with limited flexibility.

Prevention of ACL injury is a topic that has been given much attention by the sports medicine community. Various ACL injury prevention programs have been developed, and some types of training have been found to be effective in reducing ACL injury risk.[4] ACL injury risk has been associated with environmental, hormonal, anatomical, and biomechanical factors. Strategies to address biomechanical risk factors that are modifiable should be thoroughly investigated.[1]

The purpose of this report is to review the findings of a study that analyzed the association of ankle dorsiflexion with changes in jump landing mechanics. Because most ACL injuries result from a noncontact mechanism that may be preventable (e.g., jump landing), it is important to understand the rationale for measures that may modify risk. Specifically, the purpose of the study reviewed was to determine whether or not a relationship exists between the amplitude of passive ankle dorsiflexion and ACL strain during jump landing.

Variables analyzed included knee-flexion displacement, knee-valgus displacement, and peak vertical ground reaction force (GRF) and antero-posterior GRF that occur during the loading phase of jump landing (i.e., from initial contact to maximum knee flexion). The authors (Fong et al.) hypothesized that ankle joint flexibility, specifically a large amplitude of sagittal plane dorsiflexion, would characterize a jump landing that reduces the potential for ACL injury. If such an association exists, clinical measurement of passive ankle dorsiflexion might be used as a screening tool to identify athletes who possess elevated risk for ACL injury, and corrective exercise and training strategies could be employed to modify ACL injury risk.

Summary of Methods

The study included a sample of 35 physically active individuals (17 men, 18 women; mean age = 20.5 years). Exclusion criteria included a history of lower extremity injury within the previous six months, a chronic neurological or lower extremity orthopedic condition, or a history of lower extremity surgery. All testing procedures involved the subject's self-identified dominant leg.

Each subject had passive dorsiflexion of the dominant ankle measured in both flexed-knee and extended-knee positions using a standard goniometric procedure. All testing was done by the same investigator and repeated five times. Subjects were given the opportunity to practice the landing task three times to become familiar with the task.

Kinematic data were acquired by a Vicon motion capture system (Vicon Motion Systems, Centennial, CO) and a force plate quantified peak GRFs during the loading phase of the jump landing. Subjects performed a drop jump from a box that was positioned 30 cm above the force plate and were instructed to land on both feet with the dominant foot positioned over the force plate.

Means and standard deviations were reported for each of the dependent variables. Bivariate correlations were calculated to identify any meaningful relationships among the variables.

Study Findings

The majority of biomechanical research relating to ACL injury prevention has focused on knee and hip joint ROM, with relatively little emphasis on the role of ankle joint biomechanics. Neuromuscular control of the lower kinetic chain involves a complex integration of muscle actions that influence the relative positions of the foot, ankle, knee, and hip. When the alignment of one segment of the kinetic chain is altered, the function of other segments is affected. The referenced study highlights the relationship of ankle flexibility to the magnitude of GRFs acting on the knee joint.

Statistically significant, but relatively weak, correlations were found between extended knee passive ankle dorsiflexion and knee flexion displacement during landing, as well as vertical and antero-posterior GRFs. No statistically significant relationship was found between extended-knee passive dorsiflexion and knee valgus displacement. This indicates that restricted ankle dorsiflexion results in less sagittal plane knee flexion, but it does not appear to affect valgus displacement of the knee in the frontal plane. Reduced knee flexion during the loading phase of jump landing was associated with a more "upright" posture that generated greater peak GRFs. No meaningful correlations were found between flexed-knee passive ankle dorsiflexion and any other jump landing variable.

Clinical Relevance of the Findings

The results suggest that ACL injury risk may be reduced with increased ankle flexibility. A large amplitude of passive ankle dorsiflexion may enhance dissipation of peak GRFs. Generation of high peak GRFs have been reported to increase risk for non-contact ACL injury.[5] The study results suggest a mechanism by which athletic trainers and therapists might address a modifiable risk factor for ACL injury. Athletic trainers and therapists should ensure that flexibility of the gastrocnemius and soleus muscles has been completely restored following ankle injury.

A large amplitude of knee flexion displacement during the loading phase of ground contact is a factor that has been shown to help protect the ACL from injury.[6] Eccentric quadriceps control of knee flexion may facilitate a less abrupt imposition of ACL loading upon landing. With a small amount of knee flexion, athletes land in a more upright posture that generates larger peak GRFs. Such a jump landing technique may exacerbate sagittal plane shear forces imposed on the ACL, thereby elevating injury risk.[7]

Interestingly, the study found no association between flexed-knee passive ankle dorsiflexion and knee flexion displacement or peak GRFs. The researchers speculated that this difference might be attributed to the influence of the gastrocnemius muscle on knee joint kinematics. The muscles that primarily affect ankle dorsiflexion flexibility are the gastrocnemius and the soleus. Both muscles act as plantar flexors of the ankle, but the gastrocnemius muscle also crosses the knee joint. Because the gastrocnemius imposes greater resistance to ankle dorsiflexion with the knee in an extended position, an ACL injury prevention program should include ankle flexibility exercises that specifically address gastrocnemius flexibility.