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SPECIAL COMMUNICATION

Is There a Potential Relationship Between Prior Hamstring Strain Injury and Increased Risk for Future Anterior Cruciate Ligament Injury?

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Abstract

Hamstring strain injuries (HSIs) are the most prevalent injury in a number of sports, and while anterior cruciate ligament (ACL) injuries are less common, they are far more severe and have long-term implications, such as an increased risk of developing osteoarthritis later in life. Given the high incidence and severity of these injuries, they are key targets of injury preventive programs in elite sport. Evidence has shown that a previous severe knee injury (including ACL injury) increases the risk of HSI; however, whether the functional deficits that occur after HSI result in an increased risk of ACL injury has yet to be considered. In this clinical commentary, we present evidence that suggests that the link between previous HSI and increased risk of ACL injury requires further investigation by drawing parallels between deficits in hamstring function after HSI and in women athletes, who are more prone to ACL injury than men athletes. Comparisons between the neuromuscular function of the male and female hamstring has shown that women display lower hamstring-to-quadriceps strength ratios during isokinetic knee flexion and extension, increased activation of the quadriceps compared with the hamstrings during a stop-jump landing task, a greater time required to reach maximal isokinetic hamstring torque, and lower integrated myoelectrical hamstring activity during a sidestep cutting maneuver. Somewhat similarly, in athletes with a history of HSI, the previously injured limb, compared with the uninjured limb, displays lower eccentric knee flexor strength, a lower hamstrings-to-quadriceps strength ratio, lower voluntary myoelectrical activity during maximal knee flexor eccentric contraction, a lower knee flexor eccentric rate of torque development, and lower voluntary myoelectrical activity during the initial portion of eccentric contraction. Given that the medial and lateral hamstrings have different actions at the knee joint in the coronal plane, which hamstring head is previously injured might also be expected to influence the likelihood of future ACL. Whether the deficits in function after HSI, as seen in laboratory-based studies, translate to deficits in hamstring function during typical injurious tasks for ACL injury has yet to be determined but should be a consideration for future work.

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Hamstring strain injuries (HSIs) are the most common injury sustained by elite athletes in a number of sports. For example, during the 2011 season of the elite Australian football competition, the average incidence of HSIs per club was 4.8 per season, resulting in 16.5 player games missed per club in the same season.[1] Similar data have been reported in the professional rugby league and rugby union.[2,3] In contrast, the incidence of new anterior cruciate ligament (ACL) injuries per club was significantly lower at 0.9 for Australian football and 0.4 for the professional rugby union per season.[1,3] However, the consequences of ACL injury are potentially much more serious because they can result in prolonged absences from training and competition as well as an increased risk of developing osteoarthritis in later life.[4,5] Therefore, both HSIs and ACL injuries present a considerable burden and risk to the success of both sporting clubs and athletes, making them key targets for prevention programs. Evidence exists that points to a relationship between ACL injury and HSI.[6,7] Verrall et al[7] reported that Australian footballers with a past history of severe knee injury (including injury to the ACL) displayed an odds ratio for future HSI of 5.6 (95% confidence interval, 1.1−28.1). The authors postulated that

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these injuries, the subsequent rehabilitation program, or both could result in altered biomechanics of the lower limbs with a resultant increase in the risk of HSI.

To our knowledge, however, very little attention has been given to the potential for previous HSI to increase the risk of sustaining an ACL injury. HSIs are known for high rates of injury recurrence; therefore, recent research has focused on the impact of HSI on neuromuscular hamstring function.[8-15] If neuromuscular hamstring function is altered after injury, this may offer a possible explanation as to why HSIs are so prone to reinjury.[16] Furthermore, given that hamstring function is important for "unloading" the ACL from ground reaction force and subsequent anterior tibial translation during foot plant, it is feasible that neuromuscular dysfunction of the hamstring muscles after HSI may also lead to an increased risk of ACL injury. This theory is supported by research that has reported neuromuscular deficits in the female hamstring, and the fact that ACL injuries are far more prevalent in women athletes compared with men athletes.[17] As such, this clinical commentary aims to present a neuromuscular case that suggests previous HSI could increase the risk of future ACL, by drawing parallels in hamstring dysfunction in previously hamstring strain–injured athletes and women athletes. The known mechanisms for ACL injury, the pertinent neuromuscular deficits reported in the female hamstring, and the reported maladaptations associated with prior HSI will be discussed briefly. The impact of these maladaptations after HSI will then be integrated with the known deficits in neuromuscular function of the female hamstring and the reported mechanisms for ACL injury to suggest a link between prior HSI and the likelihood of future ACL injury. Finally, the impact of which specific hamstring muscle is injured and how that may influence the likelihood of future ACL injury will be discussed, along with what future questions need to be pursued.

Mechanisms of ACL injury

ACL injury typically occurs at foot plant with concurrent low knee flexion angle, knee joint rotation, and valgus collapse.[17] This kinematic profile is thought to elongate the ACL and also result in increased shear forces of the femur over the tibia, resulting in greater anterior tibial translation.[17] In noncontact ACL injuries in field sports, this kinematic profile is most commonly seen when changing direction while running—specifically, when executing a sidestep cutting maneuver.[17-19] The balance of activation between the hamstring and quadriceps groups plays an integral role in the avoidance or realization of the aforementioned injurious kinematic extremes.[18,20,21] Electromyography studies have shown that when executing sidestep cutting maneuvers, both hamstring and quadriceps myoelectrical activity and joint loading increase significantly.[18,21] Not surprisingly, these studies have also shown that the kinematic extremes observed when noncontact ACL injuries occur are more easily reached when total hamstring activity relative to quadriceps activity is reduced.[18,20,21] The reduced activity of the hamstrings relative to the quadriceps is likely to reduce the knee flexion angle; therefore, increased ground reaction force will pass through the knee joint, and greater shear force of the femur over the tibia will ensue and, subsequently, anterior tibial translation. Thus, the strength and neuromuscular function of the hamstring muscle group is critical for the prevention of noncontact ACL injury.[17] Of further interest are the changes in activation and loading patterns of the medial (semitendinosus [ST], semimembranosus [SM]) and lateral (biceps femoris [BF]) hamstring muscles. When changes of direction are executed during running, the medial and lateral hamstrings contribute differently to knee stability; ST and SM are responsible for internal rotation and varus stress about the knee, and BF is responsible for external and valgus rotation.[18,20,21] Compromised function of the medial or the lateral hamstrings will reduce net hamstring activation relative to quadriceps activation and may lead to elongation of the ACL and the potential for injury.

List of abbreviations:

ACL anterior cruciate ligament
BF biceps femoris
HSI hamstring strain injury
SM semimembranosus
ST semitendinosus

Neuromuscular characteristics of the female hamstring

Numerous studies have identified divergence in neuromuscular hamstring function of the woman and man athlete, particularly after puberty.[22] Relevant to the proposed hypothesis, from a neuromuscular perspective, these studies have examined the coactivation of the hamstrings and quadriceps, the hamstrings-to-quadriceps strength ratio, the preactivation of the hamstrings before potentially injurious tasks, and the difference in lateral-to-medial hamstring activation patterns. Compared with men athletes, women have been found to display lower hamstring-to-quadriceps strength ratios during isokinetic knee flexion and extension,[23] which corroborates with observations of increased activation of the quadriceps compared with the hamstrings during a stop-jump landing task,[24] a greater time required to reach maximal isokinetic hamstring torque,[25] and lower integrated electromyographic hamstring activity during a sidestep cutting maneuver.[26]

Maladaptation after HSI

Previous HSI has consistently been identified as the primary risk factor for future HSI,[27,28] and while this has been classified as a nonmodifiable risk factor, several functional deficits have been identified in athletes with a history of HSI.[16] These neuromuscular maladaptations include but are not limited to the following: lower eccentric knee flexor strength (10%–24%)[9,10]; lower voluntary myoelectrical activity during maximal knee flexor eccentric contraction (18%–20%)[11,15]; lower knee flexor eccentric rate of torque development (39%–40%)[12]; lower voluntary myoelectrical activity during the initial portion of eccentric contraction (19%–25%)[12]; and lower functional hamstrings-to-quadriceps ratio (19%).[9] Many of these factors, if left unattended, are purported to increase the likelihood of hamstring strain reinjury. However, only lower levels of eccentric strength have been identified as a risk factor for future injury.[29,30] Although these findings do not allow for the determination of whether these deficits are the cause of or the result of previous injury, they suggest that a previously injured limb exhibits alterations in hamstring muscle function compared with a contralateral uninjured limb. Of note, all of these deficits have been assessed during single-joint isokinetic dynamometry,