RISK FACTORS FOR HAMSTRING INJURIES

A CURRENT VIEW OF THE LITERATURE

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Muscle strain injuries are common in sports that involve high-intensity sprinting efforts such as the various forms of football and track and field. Acute hamstring injuries occur particularly often with a recurrence rate approaching 30% (within the same season) in Australian Rules football[1]. Despite our best efforts over the past few decades, Ekstrand and colleagues recently reported injury rates for 23 UEFA football clubs and noticed no change over a 7-year period[2]. Accordingly, a better understanding of risk factors and mechanisms for injury are argued to be fundamental to any significant future inroads to injury treatment and prevention. This review summarises our current thinking on risk factors for both primary and recurrent hamstring strains and guides us to thoughts on how future research can help advance our efforts to reduce these injuries at all levels of competition and age.

GAIT ANALYSIS INSIGHTS ON HAMSTRING MUSCLE FUNCTION

Prior to an analysis of traditional risk factors for hamstring strains, a brief review of recent work detailing hamstring function during normal walking and running is presented in an effort to inform the reader of thoughts regarding muscle function that should likely be considered. Gait analyses during running demonstrate that the hamstrings undergo a typical eccentric (muscle lengthening) contraction during the last 25% of the swing phase to assist in proximal hip extension while decelerating knee extension distally, opposing the quadriceps activity[3,4]. The hamstrings remain active during the first half of the stance phase to produce hip extension and resist knee extension through a concentric (muscle shortening) contraction. It remains uncertain, however, whether the hamstrings are susceptible to injury during late swing phase, when the hamstrings are active and lengthening, or during stance, when contact loads are present. The same group[5] used forward dynamic simulations to illustrate that although peak hamstring stretch was not affected by running speed, loading of the biceps femoris increased significantly with speed and was greater during swing than stance at the fastest speed. It was concluded that the large inertial loads observed during high-speed running may make the hamstrings most

susceptible to injury during the swing phase of gait. Another group has investigated full-body kinematics and ground reaction force data of sprinting subjects to show that all three hamstring muscles reached peak length change, reaction forces and negative work (energy absorption) during the terminal phase of swing[6]. These studies collectively suggest that the hamstrings may be most susceptible to injury during the swing phase of gait. How these observations relate to risk factors for injury and treatment and prevention strategies is a topic of future investigation.

AGE

Increasing age is commonly felt to be a risk factor for hamstring injuries although the reason for this is not well-known. Three studies have reported that age is a risk factor for primary hamstring strains[7–9]. Interestingly, a recent study examined 101 young (≤20 years) and 73 older (≥25 years), Australian football players and noted using logistic regression that body weight and hip flexor flexibility were significant independent predictors of hamstring injury in players ≥25 years of age[10]. However, none of the observed differences with respect to body mass index, hip flexor flexibility, hip internal rotation and ankle dorsiflexion range of motion were predictors of hamstring injury in the younger age group. In one of the most comprehensive studies to date, risk factors for lower extremity muscle injuries were evaluated between the years 2001 to 2010 as part of the UEFA injury study[2]. A total of 1401 players from 10 countries participated and 2123 muscle injuries were documented. The highest numbers of injuries (900) occurred in the hamstrings, with the adductors being the second most common. A previous hamstring injury was the major risk factor for subsequent injury (hazard ratio 1.40; 95% CI, 1.12 to 1.75). Surprisingly, age was not a predictor of hamstring injury, perhaps due to the age and level of play of these individuals.

In conclusion, although it appears that age may be a primary risk factor, careful analysis of potential confounding variables such as flexibility and body weight could provide new insights around this important topic.

> **variables such as flexibility and body weight could provide new insights**

FLEXIBILITY AND STRENGTH

Associations with strength and flexibility and risk for hamstring injury have been conflicting. With regards to hamstring flexibility and risk for injury, studies were reviewed by Prior et al and for the most part were not noted to show any clear association between flexibility and risk for hamstring strain[11]. This may be due to a variety of factors, including non-standardised methods for assessment of muscle flexibility (sit-and-reach, straight leg raise) as well as the inability to isolate the hamstrings from likely high influential variables such as lumbo-pelvic control and pelvis range of motion. In fact, one study comparing functional rehab and core strengthening to traditional measures of hamstring strengthening and stretching showed that the former strategy was much more effective at secondary hamstring injury reduction[12]. However, the role of core strengthening and stability in primary hamstring injury prevention remains unknown at this point. Moreover, the vast majority of clinical tests used to date in the published studies are measures of static flexibility. The relationship of static flexibility to active muscle contraction and injury particularly for muscles that cross more than one joint such as the hamstrings may be less than previously claimed. While hamstring flexibility per se may not be an independent risk factor for hamstring strains, recent work has suggested that both quadriceps and hip flexor flexibility may well play a role. In at least one study, increased quadriceps flexibility was inversely associated with hamstring strains[13] while tight hip flexors were similarly associated with hamstring strains in an older population[10]. Using a computer simulation approach, Chumanov et al have noted that the iliopsoas of the contralateral leg predicted a greater effect on hamstring length than the hamstring muscle group itself[3]. These intriguing observations support the notion that the hamstrings probably should not be viewed in isolation of surrounding ipsilateral, and perhaps even contralateral, muscle groups.

Traditional thinking has been that muscle (hamstring and quadriceps) strength may be a predictor of risk for hamstring strains. The literature is varied on this idea; in fact, most studies of pre-season strength measurement (typically hamstring peak torque) have not shown differences between injured and non-injured athletes[13]. A more recent theory is that strength imbalances between agonist and antagonist muscle groups, rather than individual muscles themselves, may be a better predictor of risk for injury[14]. Theoretically this may make some sense if we consider that the hamstrings act eccentrically to decelerate the lower limb during the swing phase of running. At the same time, if an athlete is quadriceps-dominant, this may place greater responsibility on the hamstrings during the swing phase to overcome the forces generated by the quadriceps.

While an intriguing thought with some theoretical basis, the exact ratio of hamstring: quadriceps strength needs to be determined and would likely vary based on sport, functional demands etc for individual athletes. Recent work has begun, in fact, to investigate this theory. In a prospective study of 100 professional soccer players[15], variables such as side-to-side difference (>15%) in eccentric and concentric hamstring and quadriceps strength were implemented in a logistic regression analysis to show that eccentric isokinetic hamstring strength asymmetry was the most predictive variable for subsequent hamstring strain (odds ratio 3.88, 95% CI, 1.13 to 13.23). However, a case-control study of first-year professional football players from the National Football League concluded that hamstring-to-quadriceps isokinetic strength evaluation did not predict subsequent risk for hamstring injury in the subsequent season beginning 4 months after the evaluation[16].

PREVIOUS INJURY

A recent systematic review of the literature limited to randomised, controlled trials and cohort (prospective and retrospective) studies was recently performed searching MEDLINE, AMED, SportDiscus and AUSPORT[11]. Twenty-four articles met inclusion and confirmed that previous strain, older age and ethnicity were significant risk factors for future hamstring injury. Overall, methodological quality was typically moderate with no justification of sample size being the most common limitation. Despite this limitation, there was a very strong association between previous hamstring strain and risk for subsequent hamstring injury. In general, athletes with a history of hamstring strain were two to six times more likely to suffer a subsequent similar injury with the highest risk in the first 8 weeks following return to sport. Studies were from across a variety of sports including Australian Rules football, Scandinavian football and USA football. This finding agrees with the work of Orchard et al demonstrating the highest risk for re-injury within the first 3 to 4 weeks following return[1]. The reasons for this increased risk are likely many including:

1. incomplete healing (not seen by imaging such as MRI),
2. formation of scar tissue,
3. ongoing neuromuscular deficits,
4. ongoing functional compensations.

While most hamstring strains involve the biceps femoris, the muscle that is injured does not always predict the location or severity of recurrence. Interestingly, a significant increased risk persisted for at least 1 year in two of the seven studies cited in the Prior review[11]. Furthermore, Australian Rules footballers with a previous calf strain were 1.37× more likely to suffer a hamstring strain. This observation would fit with the concept that the entire kinetic chain should be considered in assessing injury risk and safe return to sport following an injury. Future studies should address all of these variables to determine the exact cause(s) for this high risk of re-injury. Moreover, it is highly likely that a more integrated model of injury risk that takes into account all of these factors and their interaction would prove valuable in future assessment for injury risk and prevention. Researchers have attempted to decipher these relationships amongst the variables. In a prospective cohort of 508 Norwegian soccer players, 76 hamstring injuries involving 65 legs (61 players) were registered. Univariate analyses revealed previous hamstring injury (odds ratio 2.62; 95% CI, 1.54 to 4.45) and age (odds ratio 1.25; 95% CI, 0.96 to 1.63) as predictors of injury risk[17]. In a multivariate analysis of the same data, previous hamstring injury (odds ratio 2.19; 95% CI, 1.19 to 4.03) was the most important risk factor for subsequent injury[17]. Interestingly, using this multivariate approach, variables such as age, player position, hamstring muscle strength and level of play were not associated with increased risk for hamstring injury. The reason why factors such as age were significant in the univariate analysis and not the multivariate analysis is unknown at this time. Another study of Australian footballers recently confirmed the same finding that hamstring injury within the previous 12 months conferred an increased risk (adjusted odds ratio 19.6; 95% CI, 1.5 to 261.0) for subsequent injury[18].

RISK FACTORS FOR RECURRENT INJURY

Recently, prospective studies on risk factors for re-injury following acute hamstring injury were systematically reviewed by de Visser

"Athletes with a history of hamstring strain were more likely to suffer a subsequent similar injury"

and colleagues[19]. Of the 131 articles identified, five (recurrence rate 13.9 to 63.3%) met the inclusion criteria and were subsequently assessed for quality and methodological rigor. Limited evidence from this review suggests that patients with an MRI measured larger volumes of muscle involvement, grade 1 initial injury and previous ipsilateral ACL reconstruction, independent of graft choice, were risk factors for re-injury. It should be noted that none of these five studies corrected for possible confounding variables leaving the authors of the opinion that these five studies were of low methodological quality. Even more recently, a systematic review including seven studies of male adult soccer players included both a univariate and multivariate analysis to confirm that previous injury is most strongly associated with subsequent hamstring injury[20]. In this study, as well as many others, age and hamstring flexibility were not found to be major independent risk factors for hamstring injury.

SUMMARY

The strongest risk factor for hamstring strain injuries appears to be a previous history of hamstring injury. Both univariate and multivariate analyses have supported this observation. The role of other possible intrinsic and extrinsic risk factors remains a topic of ongoing dilemma as to their actual roles in predicting injury. Considerable debate exists as to whether this is due to inadequate rehabilitation and/or returning to sport too early, or simply the injury itself and intrinsic problems such as neuromuscular alterations that may place the injured muscle group at risk for a prolonged period of time. Prospective studies with sufficient sample sizes and potential variables for injury prediction are needed to conduct multivariate statistical analyses that will account for these individual variables and how they interact to predict injury.

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