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Eccentric hamstring strength deficit and poor hamstring-to-quadriceps ratio are risk factors for hamstring strain injury in football: A prospective study of 146 professional players

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ABSTRACT

Objectives: The purpose of this study was to investigate whether preseason isokinetic strength measures were predictive of future HSI among professional football players.
Design: Prospective cohort study, Level of evidence 2.
Methods: A total of 169 professional players participated in a preseason isokinetic strength screening, followed by a 10-month competitive season. Testing protocol included the concentric performance of both knee flexion and extension at 60 deg s^{-1} and 240 deg s^{-1} and the eccentric performance of the knee flexor at 30 deg s^{-1}. Strength deficits, bilateral differences, and hamstring to quadriceps strength ratios were computed. Univariate and multivariate logistic regressions were used to identify potential risk factors of HSI. Receiver operating characteristic (ROC) curves were used to investigate the sensitivity and specificity of the strength measures.
Results: Forty-one acute HSIs were sustained, and 12% (n = 5) reoccurred within the study period. In the multivariate analysis, we have shown an association between the injury risk and eccentric hamstring peak torque below 2.4 N m kg^{-1} (OR = 5.59; 95% CI, 2.20–12.92); concentric H/Q ratio below 50.5% (OR = 3.14; 95% CI, 1.37–2.22); players with previous injury of HSI (OR = 3.57; 95% CI, 3.13–8.62). ROC analysis displayed an area under curve (AUC) of 0.77, indicating fair combined sensitivity and specificity of the overall predicting model.
Conclusions: Professional football players with significant lower isokinetic hamstring strength, lower hamstring-to-quadriceps strength ratio, and a previous injury of HSI were linked to an increased risk of acute HSI.

1. Introduction

Hamstring strain injuries (HSI) remain a significant concern in professional football, because of the amount of time away from the sport and a declined level of performance for the injured athlete. HSI represent 10–12% of overall injuries and more than one-third of all muscle injuries in elite soccer.[1,2] The injury incidence of HSI has increased over the past decade.[3] The recurrence rates range from 12% to 41% during the first year of returning to play.[4–6] Understanding the multifactorial risk factors and mechanisms of this injury are crucial for developing effective injury prevention measures.[7,8]

The majority of the HSI in elite football players occur during high-speed running, which involves rapid eccentric hamstring muscle contraction.[9,10,6] Intrinsic risk factors leading to an increased risk of HSI may be identified from previous studies. Such risk factors include previous injury of HSI,[11,12,4,13–16] older age,[14,15,17] reduced hamstring strength,[17,18] reduced quadriceps strength,[19,18] lower hamstring to quadriceps (H/Q) strength ratio,[20,21,19,22] bilateral difference in hamstring fascicle length,[23] and bilateral difference in hamstring strength,[17,19] but results from different studies are conflicting. Variations in methodology and testing protocols compromise the comparison between published data in the literature, which may contribute to those contradicting results.[21]

A large prospective cohort study on professional football players has shown lower isokinetic eccentric hamstring strength at 60 deg s^{-1} (OR = 1.4; 95% CI, 1.0–1.9; p = 0.04) and lower concentric isokinetic quadriceps strength at 60 deg s^{-1} (OR = 1.4; 95% CI, 1.0–1.9; p = 0.04) as weak risk factors of HSI, while bilateral difference of hamstring strength measures were not.[18] Croisier et al.[21]

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suggested that a concentric H/Q ratio (Con 60/Con 60) lower than 0.55 is associated with injury risk of HSI (RR = 2.89, 95% CI, 1.0–8.3, $p < 0.05$). Fousekis et al.[13] found that eccentric isokinetic hamstring strength asymmetries at 60 and 180 deg s^{-1} correlated with increased risk of HSI, while H/Q ratio (Ecc 180/Con 180) did not. A meta-analysis study suggested that hamstring peak torque and hamstring-to-quadriceps (H/Q) ratio require further research to warrant their involvement in HSI because of inconclusive results, or small sample sizes.[14]

Despite an ample amount of literature exploring the topic, the relationship between hamstring injuries and isokinetic strength deficits remains controversial. The primary aim of this study was to investigate whether preseason isokinetic strength measures were predictive of future HSI among professional football players. The secondary aim was to determine potential risk factors and their confounding factors that associated with increased risk of HSI.

2. Methods

The prospective cohort study was approved by the university clinical research ethics committee. The sample consisted 169 professional football players, who were from six teams of the top national football league. These teams had football training every day and 1–2 weekly official matches during the competitive season. Players who participate in the first-team training were invited and signed written informed consents.

Players participated in the isokinetic testing session during the pre-season period. The participant was instructed to have a 10-min warm-up, including pedalling on a stationary bike and performing dynamic stretches on knee flexors and extensors. A Biodex III dynamometer (Biodex Multi-joint System 3, Biodex Medical Systems, USA) was used to take the measurements. This study adopted the testing protocol from a previous investigation.[21,24] It included the concentric performance of both quadriceps and hamstring muscle groups at 60 deg s^{-1} and at 240 deg s^{-1} (5 repetitions) and the eccentric performance of the hamstrings groups at 30 deg s^{-1} (5 repetitions). Before each assessment, the participants performed four submaximal trials to familiarise themselves with the protocol. Each part of the test was separated by a 1-min rest. The participant did not receive any visual feedback during the test. The highest peak torque in Newton meters (N m) of each measure was used. Both the dominant and non-dominant legs were tested. Three hamstring-to-quadriceps (H/Q) peak torque ratios were established for the different modes and speeds of contraction based on the previous study.[21] It included low-speed H/Q concentric ratio (Con 60/Con 60), high-speed H/Q concentric ratio (Con 240/Con 240), and functional H/Q ratio (Ecc 30/Con 240).

This study design followed the recommendation on injury data collection procedures as outlined by Fuller et al.[25] Demographic information such as height, weight, and age was collected during the last two weeks of the preseason period. We had explained the definitions of various types of injury and the procedure for the injury data collection to all of the team medical staff and coach representatives. Injury data was recorded by team physiotherapist and athletic trainers and was collected monthly.

An HSI is defined as an acute pain in the posterior thigh which causes an immediate cessation of match play or training. The injury is usually later confirmed by team medical staffs through clinical examination.[18] Moderate and severe injuries (expected day-loss greater than 7 days) were checked by Orthopaedics specialists, who diagnosed these injuries using clinical tests and medical imaging.

Univariate analyses were performed between the injured and uninjured players by independent t-tests. The injured players also had their injured limbs compared with their uninjured limbs, by student t-tests. Since the player, and not the leg, was the unit of some strength measurement comparisons, the average peak torques of both limbs were used in the uninjured group. The absolute and relative peak torque values (N m and N m/kg) were used as previously described.[17] The magnitude of differences between groups was expressed as the standardized mean difference (Cohen effect size, ES). 95% of the confidence interval was calculated for the ES. The magnitude of the ES was interpreted as 0.0–0.2, trivial; 0.2–0.6, small; 0.6–1.2, moderate; 1.2–2.0, large; and >2.0, very large.[26] Univariate odd ratios and CIs for HSI were calculated for the previous history of HSI, age, weight, height, playing position, preseason hamstring strength measures, strength imbalance and hamstring to quadriceps ratios.

Given the multifactorial nature of HSI, a multivariate logistic regression model was developed to identify the risk factors. Variables were entered into the model based on the results of univariate odds ratio analysis ($p < 0.1$). Each continuous strength variable was discriminated into either a high group or a low group based on a cut-off value, which were determined using receiver operator characteristic curves (ROC). The area under the curve (AUC) suggested how well the strength variables were able to discriminate between injured and uninjured groups. It was interpreted as excellent (0.90–1.00), good (0.8–0.90), fair (0.70–0.79), poor (0.60–0.69), or fail (0.50–0.59).[27] The level of significance was set at $p < .05$. All statistical analyses were analysed using SPSS (version 20.0, SPSS Inc., Chicago, Illinois). Data are presented as mean ± standard deviations (mean ± sd) or 95% CI unless otherwise noted.

3. Results

Twenty-three players who were unable to complete the isokinetic strength test were excluded from this study. A total of 146 professional football players (age, 24.2 ± 4.4 years.; height, 177.7 ± 5.9 cm; weight, 72.9 ± 8.65 kg; playing experience, 4.53 ± 3.65 years.) participated in this cohort study. Forty-one hamstring injuries (23 Right and 18 Left) were recorded. Among the 41 hamstring injuries, 56% (n = 23) were on the dominant side, and 12% (n = 5) recurred within the study period. The average time lost due to injury was 17.5 days (SD = 15.0 days, range = 2–90 days). 56% (n = 23) of the injuries occurred during match play, and 78% (n = 32) were non-contact injuries. No injuries were sustained during the isokinetic strength testing sessions.

Table 1 depicts the preseason isokinetic strength profile comparisons within both the limbs of the injured players and between the injured and uninjured groups. We observed that uninjured players had significantly stronger isokinetic hamstring peak torque and higher H/Q ratio at various modes and speed ($p = 0.001$–0.02, $d = 0.43$–0.80) than that of injured players. There were no differences in isokinetic quadriceps strength between two groups ($p = 0.31$–0.91, $d = 0.06$–0.22). Among the 41 injured athletes, we detected no significant side-to-side differences between the injured and uninjured contralateral leg in any strength measures ($p = 0.06$–0.68, $d = 0.09$–0.43).

The univariate odds ratios of the demographic data and the isokinetic strength variables are listed in Table 2. We have identified that previous injury, older age, weaker preseason absolute and relative isokinetic hamstring strength at different angular speed (Con 60 deg s^{-1}, Con 240 deg s^{-1}, and Ecc 30 deg s^{-1}), lower hamstring to quadriceps strength ratio, and greater between-limb imbalance of eccentric hamstring strength as the potential risk factors.

Three variables out of twelve were identified as the significant risk factors by the multivariable logistic regression (Table 3). Odd ratios (95% CI) show the degree of increased risk that compared with the referent group. The two strength related cut-off values were determined by the ROC (AUC = 0.70–0.71; sensitivity = 0.68; 1−specificity = 0.29–0.39). These results show a 5.6-fold higher

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