The Usefulness of Eccentric Hamstring Strength as a Hamstring Injury Predictor: A Critically Appraised Topic

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Clinical Scenario: Hamstring injuries are prevalent in sports and there have been many identified risk factors for hamstring injuries. Eccentric hamstring strength as a hamstring injury risk factor has been investigated. ***Clinical Question:*** Is eccentric hamstring strength an effective predictor of hamstring injuries in athletes? ***Summary of Key Findings:*** A search was performed on current literature on using eccentric hamstring strength as a predictor for hamstring injury. Three articles met the search criteria and were included in this critically appraised topic. Two studies found no correlation between eccentric hamstring strength and the prevalence of hamstring injuries. One study demonstrated that subjects who could not perform a nordic hamstring exercise beyond 30 degrees were at higher risk for injury. ***Clinical Bottom Line:*** All the risk factors, not just eccentric hamstring strength, should be combined to identify those that are at risk of hamstring injury. ***Strength of Recommendation:*** B based on the Strength of Recommendation Taxonomy (SORT) scale.

Clinical Scenario

Hamstring injuries (HSI) represent 39% of reported sports injuries and many HSI are at risk for re-injury.[1] Studies have found that a lack of eccentric hamstring strength, strength that occurs while the muscle is lengthening, can be a factor leading to HSI.[2] Previous studies have looked at using eccentric hamstring strength training for rehabilitation of HSI and eccentric exercise as an injury prevention technique.[1,2] One commonly utilized eccentric exercise is the Nordic hamstring exercise (NHE). The NHE has the patient kneeling on a pad with the ankles held in place by a partner or other immovable object. The patient then controls the body forward towards the floor while holding the spine in a neutral position, only extending the body at the knees.[3]

Clinicians have utilized pre-season physical exams to attempt to identify predispositions to decrease the risk of injury.[5] These predispositions include non-modifiable and modifiable risk factors. Non-modifiable factors for HSIs, such as age and previous HSIs, and modifiable factors, such as muscular strength, muscle imbalances, and flexibility, can all be examined in these pre-season physicals to determine who might be at risk of HSI.[5] Identifying the modifiable risk factors can direct training programs and help an athlete to understand interventions that can be implemented to decrease the risk of injury. This critically appraised topic (CAT) examined whether there is a correlation between pre-season eccentric hamstring strength and HSIs and if it can be used as an injury predictor.

Focused Clinical Question

Is eccentric hamstring strength an effective predictor for hamstring injuries in athletes?

Search Strategy

Terms Used to Guide the Search Strategy

- Patient/client group: athletes
- Intervention: eccentric hamstring strength

- Comparison: hamstring injury prevalence
- Outcomes: injury prevention

Sources of Evidence Searched

- PubMed
- Cochrane
- EbscoHost

Inclusion and Exclusion Criteria

Inclusion Criteria

- Studies published since 2017
- Full text available
- Studies that included eccentric hamstring exercise or nordic hamstring exercise measures
- Level 2 or higher evidence based off of the SORT[7] grading scale and Level 3 or higher on the OCEBM[6,8] scale.
- Limited to English

Exclusion Criteria

- Systematic reviews
- Meta analyses
- Looked at NHE as an injury prevention technique.
- Studies that provided an injury prevention protocol or intervention

Evidence Quality Assessment

The studies included in this CAT met the inclusion and exclusion criteria. Studies were assessed by the authors (KW, JS) using the Oxford Centre for Evidence-Based Medicine (OCEBM) to assess and rank the quality of the research. Assessment of the included articles can be found in Table 1.

Table 1 Summary of Study Designs and Articles Retrieved

	Van Dyk et.al.[3]	**Opar et.al.[4]**	**Shalaj et.al.[5]**
Study design	Prospective cohort study	Prospective cohort study	Prospective cohort study
Level of evidence[6,7,8]	SORT Level 2 OCEBM Level 3	SORT Level 2 OCEBM Level 3	SORT Level 2 OCEBM Level 3

Results of Search

Summary of Search, Best Evidence Appraised, and Key Findings

The literature was searched for studies that examined using Nordic Hamstring Exercise (NHE) or eccentric hamstring exercise strength as a predictor for hamstring injuries (HSI) for athletes.

- The initial search yielded 15 studies, but articles that did not investigate eccentric hamstring strength as an injury predictor were excluded.
- The articles that explored NHE as an injury prevention technique were not included.
- All three of the included studies were prospective cohort studies.[3,4,5]
- Three relevant studies met the inclusion criteria and therefore were included.

Key Findings

Van Dyk et.al.[3] and Opar et.al.[4] found no significant differences with eccentric hamstring strength and the presence of hamstring injuries while Shalaj et.al.[5] found that the athletes that could not perform a Nordic hamstring strength test beyond 30 degrees had higher association with hamstring injuries. Table 2 reports the findings of each study.

Table 2 Characteristics of Included Studies

Characteristics	van Dyk et.al.[3]	Opar et.al.[4]	Shalaj et.al.[5]
Participants	413 male soccer athletes from the Qatar Stars League (QSL) from 2 seasons were included in the study (68.2% of all QSL players). Mean age 25.8+-4.8 years, mean height 177+-7cm, weight 72.4 +-9.3kg, BMI 23.1 +-2. Previous HSI was reported by the athletes.	Members from 6 teams in the Australian football league participated in this study. 311 males totaling 455 player seasons were included 23.7+-3.8 years old, 188.1+-7.6cm tall, and 86.5+-8.8kg.	143 male soccer players from 11 teams of the Kosovo national premier soccer league were included in this study. 7 were goalkeepers, 27 internal defenders, 20 external defenders, 18 central midfielders, 23 external midfielders, 20 wingers, and 28 strikers. Mean age was 23.3+-4.1 years, mass was 74.2+-6.7 kg, height was 180.0+-5.3 cm, and BMI 22.9+-1.7kg m^{-2}. 129 had a dominant right leg, 14 had a dominant left leg.
Intervention investigated	**Isokinetic strength:** An isokinetic dynamometer was used to test knee flexion and knee extension strength. Athletes perform 5-10 minutes of a warmup on a stationary bike. The order of which leg was tested first was randomized and maintained. 5 repetitions of concentric knee flexion and extension were performed at 60	Athletes in this study did a self-selected warmup, followed by one set of 1-3 maximal repetitions of the NHE. Eccentric knee flexor strength and highest peak force produced during the testing set was collected and then scaled relative to body mass. $Limb_{max}$ was the stronger limb, and $Limb_{min}$ was the weaker limb. Biceps femoris long head (BFlh) was also examined for muscle thickness, pennation	Participants were instructed to refrain from strenuous activity 2 days prior to fitness testing. Following a 15 minute warmup of running drills without the ball the players isokinetic torque measurements, sit and reach test (SRT), Nordic hamstring strength test (NHST), and a countermovement jump, speed, and agility tests were

	degrees/second, and then followed by 10 repetitions at 300 degrees/second. Last they did 5 repetitions of eccentric knee extension at 60 degrees/second to test hamstring strength. **Dynamic control:** The specific knee flexion angle where the quadriceps torque was greater than eccentric hamstring torque was calculated. Peak torque (Nm) for concentric knee flexion and extension, and for eccentric knee extension all at 60 degrees/second, defined the dynamic control. Concentric H:Q ratio and dynamic control ratios were calculated for 30 degrees, 40 degrees, and 50 degrees. **Nordic hamstring:** One set of 3 repetition max eccentric hamstring exercise. **Injury surveillance:** Data from the previous QSL seasons was collected. Training and match exposure was recorded.	angle, and fascial length. The muscle was scanned at the halfway site between the knee joint fold and the ischial tuberosity with the athlete prone, after 5 minutes of inactivity.	performed. Tests were performed one per day in the above mentioned order, the only difference was no warmup on the day of the SRT. Biodex System 3 was used to find H:Q ratio. H:Q concentric contraction at 60 degrees per second was done for 3 reps. H:Q concentric at 240 degrees power second was done for 5 reps. Hamstring eccentric contractions at 30 degrees per second was done for 3 reps. Hamstrings eccentric contractions at 120 degrees per second was done for 4 reps. Illinois Agility Test (IAT) time was performed and the best time of 3 trials was recorded. 3 trials of 20-meter and 40-meter sprints with 5 minutes of rest were performed. SRT test was performed once. NHST was marked as “passed” if the subject could hold the position beyond 30 degrees from starting position. Countermovement jump is a vertical

	24 strength variables: 11 isokinetic strength, 5 NHE, and 8 dynamic control variables.		jump test measured by a ground reaction force plate. It was done 3 times with 2 minutes rest between and the best jump was kept for analysis.
Outcome measured	The following outcomes were gathered and analyzed via independent t-tests to determine if there was correlation between the measurements and those athletes that did or did not sustain a HSI. **Isokinetic strength:** Highest peak torque for each of the three above mentioned tests was recorded **Dynamic control:** Torque value for concentric quadriceps contraction was subtracted from the eccentric hamstring contraction, and net joint torque was the point where the net joint torque was zero. **Nordic hamstring:** Max torque was recorded. **Injury surveillance:** Data from the previous QSL seasons was collected. Training	Independent t-tests were performed on the data and the level of significance was set at $P < 0.05$. An injury report form was filled out for all HSI that gave information on which limb, injured muscle, activity type at the time of injury, number of days to fully return. The index injury was their first injury. Injury incidence rate was calculated as number of injuries per 1000 player hours in games and trainings. Significance was .05 for all tests. Ultrasound images were taken along the longitudinal axis of the muscle belly at the halfway point between the ischial tuberosity and the knee joint fold. All were taken prone after 5 minutes of inactivity. Thickness was defined as the distance between superficial and intermediate aponeurosis. Pennation angle was the angle between the	Descriptive statistics were used for baseline characteristics, means, and standard deviations. Independent t-tests compared groups. Isokinetic values were calculated by dividing absolute toque by body mass. Effect size was calculated as: small (0.2-0.3), medium (0.5), or large (>0.8). 95% confidence intervals were used and P-values <=0.05 were statistically significant.

	and match exposure was recorded.	intermediate aponeurosis and a fascicle of interest.	
Main findings	Of the 413 athletes, 66 people sustained 69 hamstring injuries. Three players sustained 2 injuries. Age (P=.002) and position (P=.02) were significant indicators for injury. Weight (P=.86), height (P=.30), BMI (P=.33), previous injury (P=.89), limb dominance (P=.39), and ethnicity (P=.16) were not found to be significant risk factors for HSI. Eccentric hamstring torque was not found to be statistically significant in those that sustained HSI.	Of the 455 player seasons assessed, 381(83.7%) did not sustain a HSI and 74 (16.3%) did. Primary mechanism for injury was high speed running (46%), acceleration/deceleration (15%), jumping and tackling (12%). 82% of the injured were BFlh, 14% were semimembranosus, 4% in the semitendinosus. Average time for return was 15 days for 88% of cases. 57% of injuries were in season, with an average return to play of 21 days. Prior HSI was associated with risk, but other demographics and previous ACL injury did not increase risk. Less relative fascicle length and large pennation angle had greater association for HSI. Lesser relative fascicle length compared to pennation angle had a higher association with HSI. Absolute fascicle length and eccentric knee flexor strength imbalance had a significant association with HSI.	31,998 training hours and 4,834 hours of match play were recorded. Average matches competed in were 25.3+-4.0. Average training sessions was 149.2+-14.3. Mean match play time was 33.8+-8.9 hours and training sessions was 223.8+-21.5 hours. 43 HSI were recorded, 16 occurred in training and 27 occurred in matches. Injury incidence for training was .50 (95% CI) and for match was 5.59 (95% CI). No significant difference for position and injury (p=0.258). 643 total days were recorded as lost due to HSI, 431 days from injuries during matches. Age was significantly higher in HSI (p<0.001). Body mass (p=0.002) and BMI (p=0.002) were higher in injured players compared to non-injured. There was a lower passing rate of NHST for the injured players

			(p=0.001) and a higher previous HSI (p=0.023). Significantly higher H:Q ratios were found for injured players for their non-dominant legs (p=0.044). No significant differences for the SRT, IAT, countermovement jump, 20-meter and 40-meter dashes. Hamstring torque in injured athletes was significantly lower for both legs compared to non-injured ones for dominant (p=0.039) and non-dominant (p=0.025).
Support for PICO?	No	No	Yes
Level of evidence[7]	1b	1b	1b
Conclusion	None of the strength variables had significant differences for those that sustained injuries during the season and those that did not. Nordic hamstring exercise had no significant differences for test variables between injured and non-injured limbs. Eccentric hamstring strength is a poor predictor for injury.	Short BFlh fascicle length correlates to increased HSI risk. Eccentric knee flexor strength and between limb differences at the start of preseason did not increase HSI risk. When assessed at multiple time points, a limb difference of >9% did correlate to increased HSI risk. Prior HSI was significantly associated with HSI.	Low passing rate for the nordic hamstring strength testing was found to be a significant factor of hamstring injuries as well as previous HSI. This indicates that eccentric hamstring strength via the NHST might be able to be used as an injury predictor in conjunction with other risk factors.

Results of Evidence Quality Assessment

All articles were graded Level 3. Each article was evaluated using the Strength of Recommendation Taxonomy (SORT) scale and given a Level 2 to all three studies. [3,4,5] The included studies had a reasonable number of participants, analyzed full seasons rather than varying time frames, and used t-tests to compare their data which helped when comparing the studies. However, the studies all measured eccentric hamstring strength differently which limits the generalizability of the results. There was inconsistent support between the studies for the PICO making the results and recommendation limited. The overall recommendation for this study is **B** based on the SORT scale.[7]

Clinical Bottom Line

Eccentric hamstring strength should not be used in isolation to try to predict those at risk for hamstring injury but should instead be used as part of a multi-factor analysis. The included studies demonstrated that eccentric hamstring strength has limited pre-season implications compared to the incidence of injuries within a season.

Implications for Practice, Education, and Future Research

There are several factors that may put someone at risk for hamstring injury and these factors should be examined together. Some factors that may cause hamstring injuries include age, previous HSI, quadriceps strength, Q:H ratio, hamstring flexibility, and balance.[3-6] Eccentric hamstring strength can be a component of those examined factors, but only if the correct tools and equipment to measure strength output are utilized. The included studies demonstrated poor consistency and evidence to support using hamstring strength as a predictor for hamstring injury.[3-5] Two studies identified that the above mentioned risk factors would be better at predicting HSI than eccentric hamstring strength.[3,4] Eccentric exercises such as the NHE, eccentric deadlifts, and slow seated hamstring curl exercise are effective at building strength pre-injury and post-injury, but should be used with caution when using eccentric hamstring strength to identify those at risk for hamstring injury.[1,2] Strength measurements may be more useful in identifying imbalances that may be utilized to implement preventative exercises to strengthen those weaknesses. Hamstring exercises, specifically eccentric hamstring exercises, can be included in pre-season protocols to help reduce the incidence of HSI.[1,2]

Future research could examine other ports populations. The included studies only looked at male soccer or football players, giving them poor generalizability to other sports and female athletes.[3-5] Further research should diversity the sample population to include a more diverse group of sports and include female participants. Future research can also examine different strength measures of other commonly injured muscles to see if identifying strength imbalances is reliable and useful for preventative strength training. Future studies could help provide better conclusiveness about using strength testing as an injury predictor. Eccentric hamstring exercises are an effective injury prevention tool and should be used for injury prevention but are a poor predictor for determining if someone is susceptible to hamstring injury.[2-5]

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