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TITLE:

HAMSTRING AND ANKLE FLEXIBILITY DEFICITS ARE WEAK RISK FACTORS FOR HAMSTRING INJURY IN PROFESSIONAL SOCCER PLAYERS - A PROSPECTIVE COHORT STUDY OF 438 PLAYERS INCLUDING 78 INJURIES.

Corresponding author:

Nicol van Dyk[1,3], PT, MSc
Rehabilitation Department
Aspetar Orthopaedic and Sports Medicine Hospital
PO Box 29222
Aspire Zone Foundation
Doha, Qatar
nicol.vandyk@aspetar.com
Telephone: ++97 44413 2000
Fax: +974 44132020

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List of co-authors and their contribution:

Dr Abdulaziz Farooq[1], MPH, MSc

Prof Roald Bahr[2], MD, PhD

Prof Erik Witvrouw[3], PT, PhD

Author affiliations:

[1]Aspetar Orthopaedic and Sports Medicine Hospital, Doha, Qatar

[2]Oslo Sports Trauma Research Center, Norwegian School of Sport Sciences, Oslo, Norway

[3]Department of Rehabilitation Sciences and Physiotherapy, Ghent University, Ghent, Belgium

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ABSTRACT

Background: Hamstring injuries remain a significant injury burden in sports such as soccer that involve high speed running. It has repeatedly been identified as the most common noncontact injury in elite male soccer, representing 12% of all injuries. As the incidence of hamstring injuries remains high, investigations are aimed at better understanding how to prevent hamstring injuries. Stretching to improve flexibility is a commonly used in elite level sport, but risk factor studies have reported contradicting results leading to unclear conclusions regarding flexibility as a risk factor for hamstring injury.

Hypothesis/Purpose: To investigate the association of lower limb flexibility with risk of hamstring injury in professional soccer players.

Study Design: Cohort study, Level of evidence, 2.

Methods: All teams (n=18) eligible to compete in the premier soccer league in Qatar underwent a comprehensive musculoskeletal assessment during their annual periodic health evaluation at Aspetar Orthopaedic and Sports Medicine Hospital in Doha, Qatar. Variables included passive knee extension and the ankle dorsiflexion lunge range of motion. A clustered multivariate Cox regression analysis was used to identify association with risk of hamstring injury. Receiver operating characteristics (ROC) curves were calculated to determine sensitivity and specificity.

Results: A total of 438 unique players (72.4% of all QSL players) competed for 601 player seasons (148 players competed both seasons) and sustained 78 hamstring injuries. Passive knee extension range of motion (hazard ratio [HR], .97; 95% CI, 0.95 to 0.99; P = .008) and ankle dorsiflexion lunge range of motion (HR, .93; 95%CI, 0.88 to 0.99; P = 0.02) were independently associated with injury risk. The absolute difference between the injured and uninjured players were 1.8° and 1.4cm respectively, with small effect sizes (d < 0.2). The receiver operating characteristics (ROC) curves analyses showed an area

under the curve of 0.52 for passive knee extension and 0.61 for ankle dorsiflexion, indicating a failed to poor combined sensitivity and specificity of the two strength variables identified in the multivariate Cox regression analysis.

Conclusion: This study identified deficits in passive hamstring and ankle dorsiflexion range of motion as weak risk factors for hamstring injury. These findings have little clinical value in predicting future hamstring injury risk, and test results must therefore be interpreted cautiously in athletic screening.

Clinical Relevance: These results suggest that there is a significant, albeit weak relationship between flexibility and risk of hamstring injuries. Since it is not possible to determine a clear cut-off point to identify a high risk group, stretching should be implemented at a group level.

What is known about this subject: Contrasting results have been reported for flexibility as a risk factor for hamstring injury, and in elite soccer, stretching is used routinely as part of standard warm up programs.

What this study adds to existing knowledge: This study identified on group level small absolute range of motion differences and wide overlap of the absolute measurements, and confirmed weak association between a flexibility deficit and risk for hamstring injury. It also evaluates the clinical significance of these findings, and makes recommendations as to the understanding of the relationship between flexibility and risk for hamstring injury.

Key words: hamstring, muscle injury, flexibility, injury prevention

INTRODUCTION

In elite soccer, hamstring injury is the most common non-contact injury reported.[17,25] The incidence of hamstring injuries remains high, and, at least at the Champions League level, even seems to rise.[18] Although there are prevention programs based on eccentric strength training indicating positive results,[3,35,46,49] the evidence supporting the use of stretching exercises aimed at improving flexibility to prevent injury is limited.[32,44,53] Nevertheless, flexibility was the most routine injury risk screening test reported by the 32 teams participating in the FIFA 2014 World Cup in Brazil.[30] Flexibility testing is also perceived by European clubs to be important; 87% of elite clubs reporting it as one of the three most commonly used injury screening tests.[31] However, prospective studies examining the relationship between flexibility and injury risk have produced conflicting results.[28,50–52]

The most comprehensive meta-analysis to date identified high quadriceps muscle strength as the only modifiable risk factor to increase the risk of hamstring injury (together with the non-modifiable factors age and previous injury).[20] Another systematic review confirmed previous injury as a risk factor, yet found conflicting evidence for age and hamstring flexibility.[48]

No association was found between various flexibility measures, like the slump test, lumbar spine flexion, lumbo-femoral ratio, straight leg raise or the sit-and-reach-test with the risk for hamstring injury.[20] However, for the active and passive knee extension tests, quadriceps flexibility and the dorsiflexion lunge test there were mixed or contradicting results, hampered by small sample sizes and large heterogeneity between the studies included in the meta-analyses.[20,48] Thus, the relationship between flexibility and risk of hamstring injury is still poorly understood, and, to date, no adequately powered study exists investigating the relationship between flexibility and risk of hamstring injury.

The purpose of this study was therefore to examine the relationship between flexibility, measured as hamstring and ankle dorsiflexion range of motion, with risk of hamstring injury in a large cohort of professional soccer players.

METHODS

Study design

Ethical approval was obtained from the Institutional Review Board, Anti-doping Laboratory, Qatar (IRB F2013000003). This study covered two consecutive soccer seasons (September 2013 to May 2015) of the Qatar Stars League (QSL), the premier soccer league and highest level of competition in Qatar. All teams (n=18) eligible to compete agreed to participate in the study. Each player from the respective teams underwent an annual periodic health evaluation (PHE) at Aspetar Orthopaedic and Sports Medicine Hospital in Doha, Qatar. The PHE was performed from May to September, with the official start of the season in September of each year. If players performed PHE outside of this period and met the inclusion criteria, they were still included in the study.

All players over the age of 18 years and eligible to compete in the QSL, who had provided written consent and were able to perform the testing, were included. Players who were injured at the time of the PHE and unable to perform the tests were excluded. If no musculoskeletal tests were performed at the start of a season, or no exposure or injury surveillance data were recorded over an entire season, players were also excluded. Figure 1 depicts the inclusion methodology during the two study seasons.
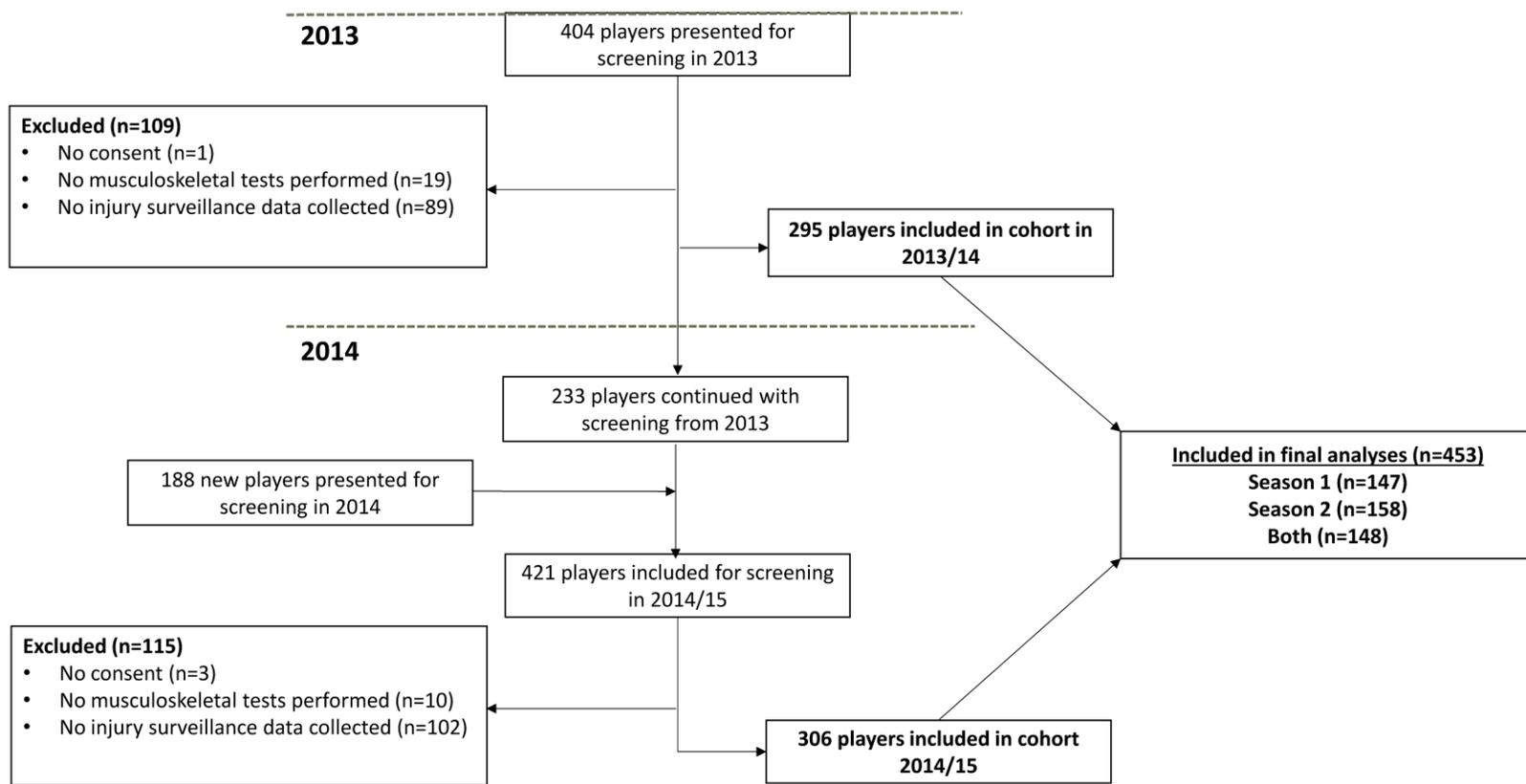
Figure 1 Flowchart demonstrating the movement of players and repeated measurements between different seasons.

Player information

Non-modifiable risk factors that were included for analysis were history of previous hamstring injury in the past 12 months, age, playing season, team, leg dominance, playing position, and ethnicity. Player height and weight were measured and body mass index (BMI) calculated during the PHE.

Flexibility tests

Active knee extension test

The active knee extension test was performed for both limbs with the player positioned in supine on an examination table and the tested hip flexed to 90°. A digital hand-held inclinometer was positioned at the anterior tibial border halfway between the inferior pole of the patella and the line between the two malleoli.[36] The player was instructed to extend his knee until reaching maximal tolerable stretch of the hamstring muscle, while the examiner maintained the position of the thigh to the vertical by reading the inclinometer (90° ipsilateral hip flexion). At the end point of maximal tolerable stretch, the absolute knee angle was measured with the inclinometer on the tibia as read out by the tester. The active knee extension test have been found to be reliable.[43]

Passive knee extension test

The passive knee extension test was performed for both limbs in the same starting position as for the active test; the hip of the tested limb positioned in 90° flexion, while the contralateral leg remained flat on the examination table. The examiner extended the knee until reaching the maximal tolerable stretch of the hamstring muscle as indicated by the tested player, while maintaining the thigh to the vertical.[36] At the end point of the maximal tolerable stretch, the absolute knee angle was measured with the inclinometer on the tibia as read out by the tester. Excellent interrater reliability and good test-retest reliability have been found for this test.[23]

Dorsiflexion lunge test

A measuring tape (in cm) was placed on the floor with the start point (0 cm) aligned to the bottom corner of the wall. The player was instructed to stand facing the wall, positioning their foot so that the heel line and big toe were aligned on the tape measure on the floor.[9] They lunged forward so that their knee touched the wall. Players were allowed to hold onto the wall for balance during the test with the untested leg free to rest in a comfortable position. The player was instructed to lunge forward moving his ipsilateral knee into flexion and touch the wall while maintaining contact between the heel and the floor. The examiner observed the maximum distance where the player could maintain this position, measuring the distance from the wall to the big toe. The measure was repeated for both the left and right side. The inter- and intra-rater reliability for this test have been reported as excellent.[9]

Injury surveillance

All participating QSL teams were provided with medical services by the National Sports Medicine Programme, a department with the Aspetar Orthopaedic and Sports Medicine Hospital. This centralized system with a focal point for the medical care of each club competing in the QSL allowed for standardization of the ongoing injury surveillance through the Aspetar Injury and Illness Surveillance Programme (AIISP).[8]

The AIISP includes prospective injury and exposure (minutes of training and match play) recorded from all QSL teams. The injury data were collected monthly, with regular communication with the responsible team physician/physiotherapist to encourage timely and accurate reporting. Throughout the 2013 and 2014 season (July to May; 44 weeks), training and match exposure for each team were recorded by the team physician (or lead physiotherapist if no team physician was available). At the conclusion of each season, all the data from the individual clubs were collated into a central database, and discrepancies were identified and followed up at the different clubs to be resolved.

A hamstring injury was defined as acute pain in the posterior thigh that occurred during training or match play, and resulted in immediate termination of play and inability to participate in the next training session or match.[47] These injuries were confirmed through clinical examination (identifying pain on palpation, pain with isometric contraction and pain with muscle lengthening) by the club medical team. If indicated, the clinical diagnosis was supported by ultrasonography and magnetic resonance imaging at the study center. A recurrent injury was defined as a hamstring injury that occurred in the same limb and within two months of the initial injury.[25]

Statistical analyses

The average of the flexibility measures, as determined by the active knee extension, passive knee extension and dorsiflexion range of motion tests, was compared between injured and uninjured players using independent t-tests. Similar comparisons were made between the injured limbs with the uninjured limbs using paired t-tests. Effect size, which is the quantitative measure of the strength of an observed occurrence, was calculated and interpreted as small (> 0.2), medium (> 0.5) or large (> 0.8).[13]

Due to the consistency in our sample, we modeled time to first hamstring injury following date of testing using Cox-regression analysis. Since our study included repeated measures performed over the two seasons, as well as the fact that not every player had the same number of measurements (i.e. some players would have test results including both limbs for both seasons, while other players might only have been tested once), standard errors would have increased when using general estimating equations in a traditional Cox regression model. Therefore, we performed a univariate Cox regression analysis using the limb as the unit of analysis, adjusting for player identity as a cluster factor (STATA (version 11.0, College Station, Texas, USA). Each individual player's exposure was computed as total duration in hours for matches and training combined from the start to the end of each season, or time to first injury. All variables with p-value ≤ 0.10 in the univariate analysis were considered further in a backward

stepwise multivariate Cox regression analysis to identify potential predictors. Hazard ratios (HR) with

95% confidence intervals (CIs) are presented with exact *P* values, and *P* values of ≤ 0.05 were considered

statistically significant.

We calculated receiver operating characteristic (ROC) curves to describe the sensitivity and specificity of

the significant flexibility variables. The area under the curve (AUC) indicates how well the strength

variables under consideration would discriminate between injured and uninjured players, and were

interpreted as excellent (>=0.90 to <=1), good (>=0.80 to <0.90), fair (>=0.70 to <0.80), poor (>=0.60 to

<0.70) or fail (>=0.50 to <0.60).[1,33]

RESULTS

Players

During the two-season study period, 592 elite male soccer players (age, 25.8 ± 4.8 years; height, 177 ± 7

cm; weight, 72.4 ± 9.3 kg; body mass index [BMI], 23.1 ± 2.0 kg/m^2) reported for screening and were

considered for musculoskeletal testing. Players who were unable to perform the test (n=45), who did

not provide consent (n=4), or had no injury surveillance data recorded during the subsequent season

(n=105) were excluded from the final analyses (n=154; age, 25.2 ± 4.7 years; height, 178 ± 9 cm; weight,

75.1 ± 9.8 kg; BMI 23.4 ± 1.9). In total, 438 unique players (72.4% of all QSL players) competed for 601

player seasons (148 players competed both seasons) (Figure 1).

New hamstring strain injuries

In total, 73 of the 438 players sustained 78 index hamstring injuries. The five players who had more than

one injury were retained in the analyses; none of these injuries met the criteria for re-injury and all

subsequent injuries were sustained in the second season. All injured players in season one had their

previous injury status adjusted accordingly in season two.

Non-modifiable risk factors

There were no differences in height, ethnicity, limb dominance, and body composition between injured and uninjured groups (Table 1). Previous hamstring injury was reported by 30.1% of the entire cohort (n = 132) with no significant difference between injured and uninjured players.

Table 1 Characteristics of injured (n=73) and uninjured players (n=365)[a]

	Injured (n=73)	Uninjured (n=365)	*P* value
Age, yrs	27.8 ± 4.1	26.2 ± 4.6	**.001**
Weight, kg	71.6 ± 7.5	72.7 ± 9.3	.15
Height, cm	175 ± 7	177 ± 7	.09
Body mass index, kg/m^2	23.3 ± 1.9	23.2 ± 2.0	.96
Previous injury, n (%)	26 (35.6)	106 (29.0)	.59
Player position, n (%)			**.02**
Goalkeeper	1 (1.4)	54 (11.9)	
Defender	29 (42.0)	144 (31.8)	
Midfielder	27 (39.1)	159 (35.1)	
Forward	12 (17.4)	96 (21.2)	
Limb dominance, n (%)			.55
Left	17 (23.3)	79 (21.6)	
Right	56 (76.7)	286 (78.4)	
Ethnicity, n (%)			.62
Arab	40 (54.8)	222 (61.0)	
Black	25 (34.2)	107 (29.3)	
Asian	2 (2.8)	6 (1.5)	
Caucasian	6 (8.2)	30 (8.2)	

[a]Data are shown as mean ± SD unless otherwise indicated. Chi-square analyses were used for categorical variables.

Univariate analyses identified age and position as potential risk factors for hamstring injury (Table 1). Goalkeepers were significantly less likely to sustain a hamstring injury than defenders, midfielders or forwards. The injured players were on average 18 months older than the uninjured players.

Range of motion tests as potential risk factors

The results from the univariate analysis are presented in table 2 for both the active and passive knee extension tests, as well as the dorsiflexion lunge test. Both the passive knee extension test and the dorsiflexion lunge test displayed a significant difference between the injured and uninjured groups. These effects were maintained when exposure was accounted for in the univariate Cox regression analysis (Table 2).

In the multivariate Cox regression analysis, both passive knee extension as well as the dorsiflexion lunge tests were retained from the univariate analyses and significantly associated with hamstring injury risk, with no influence of age and position (Table 3).

ROC analyses revealed an AUC of 0.52 and 0.61 for the passive knee extension test and dorsiflexion lunge test respectively, indicating a failed to poor combined sensitivity and specificity of the two strength variables identified in the Cox regression. The results for both variables were normally distributed, with complete overlap in the distribution of range of motion between the injured and uninjured groups for both passive knee extension range of motion and ankle dorsiflexion range of motion (Figures 2 and 3 respectively).
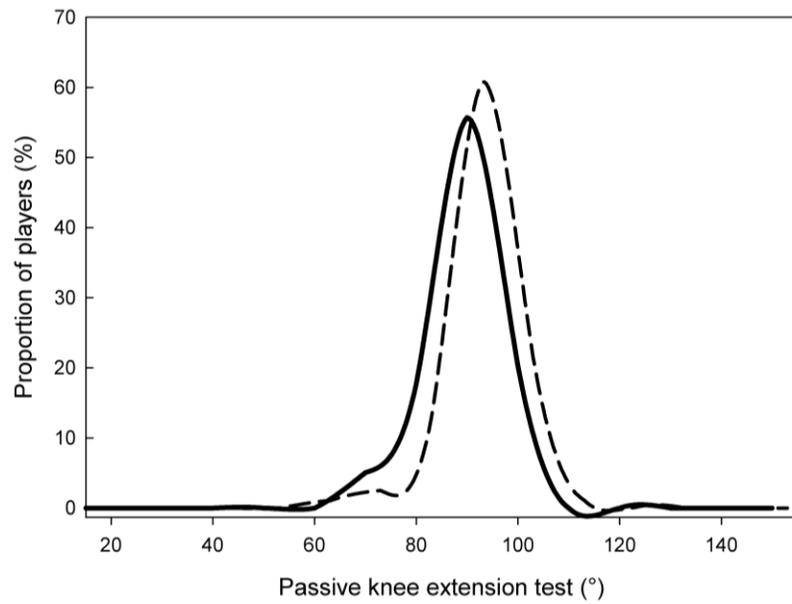
Figure 2 Distribution of passive knee extension test results (°) for the injured (solid line) vs uninjured (thatched line) groups.
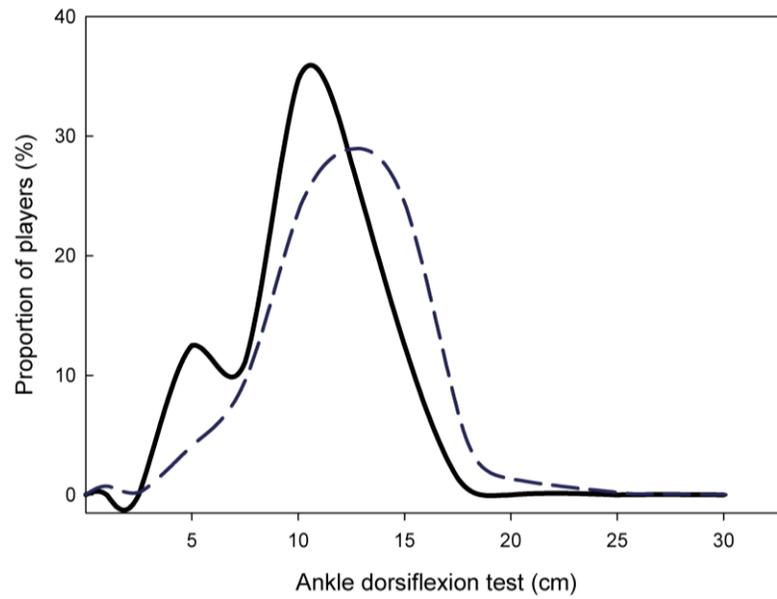

Figure 3 Distribution of the ankle dorsiflexion test results (cm) for the injured (solid line) vs uninjured (thatched line) groups

Table 2 Univariate comparison of range of motion tests between the injured and a) the uninjured limb in the injured players, b) all uninjured limbs in the uninjured players, and (c) Cox regression analysis demonstrating parameter estimates (95% confidence intervals, CI) for all range of motion variables when comparing injured to uninjured limbs.

	Injured Players				Uninjured Players			Univariate Cox regression	
	Injured limb n=78)	Uninjured limb (n=78)	Difference (95% CI)	P value[a]	Uninjured limbs (n = 1156)	Difference (95% CI)	P value[b]	HR (95% CI)	P value[c]
Active knee extension test (°)	77.3 ± 9.3	77.1 ± 8.7	0.2 (-2.7 to 3.1)	.53	78.0 ± 9.7	0.7 (-1.5 to 2.9)	.52	0.99 (0.97 to 1.01)	.30
Passive knee extension test (°)	84.4 ± 7.2	84.5 ± 7.9	0.1 (-2.3 to 2.5)	.05	86.2 ± 7.6	1.8 (0.1 to 3.5)	**.04**	0.97 (0.95 to 1.00)	**.02**
Dorsiflexion Range of motion (cm)	9.8 ± 3.1	10.3 ± 2.9	0.5 (-0.5 to 1.5)	.34	11.2 ± 3.2	1.4 (0.7 to 2.1)	**.0003**	0.89 (0.84 to 0.95)	**.0001**

Absolute values for all measures are shown as mean ± SD. Bolded *P* values indicate statistically significant difference between compared groups. HR, Hazard ratio.

Table 3 Multivariate Cox regression analysis demonstrating parameter estimates (95% confidence intervals, CI) for significant predictor variables for hamstring injuries.

	HR	95% CI	p-value
Age	1.07	1.02 to 1.11	**.002**
Position (reference group: goalkeepers)			
Outfielders	5.09	1.29 to 20.07	**.02**
Passive knee extension test	0.97	0.95 to 0.99	**.008**
Ankle dorsiflexion test	0.93	0.88 to 0.99	**.02**

Bolded *P* values indicate statistically significant difference between compared groups. HR, Hazard ratio.

DISCUSSION

This 2-season prospective cohort study, with 438 players and 78 hamstring injuries the largest to date, identified significant albeit small associations between hamstring and ankle range of motion and risk of injury. This suggests that limited flexibility represents a weak risk factor for hamstring injuries, and may be considered a causal factor. The group differences in the range of motion measures between players who went on to suffer a hamstring injury and those who did not were small, and the wide overlap between groups clearly illustrate that it is not possible to use these tests in screening to identify whether a player is at risk of hamstring injury or not.

Hamstring range of motion

Flexibility is consistently described in the literature as the outcome of range of motion tests. Although factors such as joint mobility[22] and neural dynamics[41] might influence the findings of range of motion tests, the active and passive knee extension, straight leg raise, sit-and-reach, or lumbar spine flexion tests are interpreted to represent muscle flexibility[50,53]. Therefore we might consider how these different range of motion tests compare to each other when used to determine flexibility, and risk of hamstring injury.

Recently, range of motion measured by the sit-and-reach test was found not to be associated with risk of hamstring injury,[50] while range of motion measured by the straight leg raise test has been identified as a risk factor for hamstring injury.[50] A recent meta-analysis of available prospective cohort studies found no significant difference between injured and uninjured groups for the lumbar spine flexion, sit and reach test, and straight leg raise tests.[20] Similarly, the same meta-analysis did not identify active or passive knee extension as risk factors for hamstring injury.[20] However, there are two key elements that differentiate the active and passive knee extension tests from other measures of hamstring flexibility like the sit and reach, lumbar flexion and straight leg raise tests. The latter include 1) pelvic movement

and/or 2) the knee being fixed in an extended position during the test. Due to the biarticular nature of the hamstrings, allowing the pelvis to move during the test and keeping the knee fixed might influence the resultant range of motion. The results from the knee extension test, where pelvic movement is constrained and motion occurs at the knee joint, might more accurately represent the flexibility of the hamstrings. Although the concurrent validity of these tests are poor, the knee extension test is recommended as the most valid and reliable measure for clinicians to use when the aim is to measure hamstring muscle length.[15]

The hamstrings are thought to be at greatest risk of injury during the terminal swing phase of high speed running,[39,27] as the biarticular hamstring muscle undergoes a stretch-shortening cycle in this phase of the stride cycle.[45] During the terminal swing phase, the hamstrings are lengthening, producing peak force and performing much negative work.[38] Greatest musculotendinous strain is produced during this phase, making the hamstrings susceptible to injury during the lengthening (eccentric) contraction.[12] Although pelvic movement is necessary for high speed running, the amount of anterior tilt and hip flexion does not alter dramatically in the late swing phase.[14]Although the relationship between measures of flexibility and high speed running is unknown, we might consider whether the active and passive knee extension tests might represent a more valid test for hamstring flexibility in soccer players exposed to high speed running.

Active knee extension

Our results support previous findings that range of motion during active knee extension is not associated with risk of hamstring injury. The same test has been investigated for risk of re-injury and potential delayed return to sport.[16,28,51] De Vos et al did identified an independent association with the risk for re-injury. The active component might capture different aspects of apprehension or comfort

with the movement, similar to Askling's H-test at return to sport.[5] It might reflect changes in the affected tissue that persist even when rehabilitation is completed.

Passive knee extension

Our results do challenge previous findings that fail to identify passive knee extension as a risk factor for hamstring injury.[4,19,37] There are potential reasons for the contrasting results. Although Engebretsen et al[19] did include a high number of hamstring injuries (n=65), this represented a mix of acute and overuse hamstring injuries. Also, a small absolute difference between the groups (0.5°) and a large standard error of the mean (2.1°) were reported.[19] Arnason et al[4] included less than half the number of injuries compared to our study (n=31). Interestingly, they found greater range of motion (by 3.4°) in the injured groups, again with a large standard error of the mean (2.1°). Rolls and George[37] investigated a cohort of youth soccer players, and in their small sample of only 15 injuries, they observed a difference of 4.4°, but with a standard deviation of 8.3° there is again the potential for a type II error. The inclusion of a large number of acute index injuries in our study allows for the identification of weaker associations between passive knee extension and hamstring injury than may have been possible in previous studies.

Ankle dorsiflexion range of motion

Gabbe et al found restricted ankle dorsiflexion range of motion on the lunge test to be independently associated with risk of hamstring injury,[21] albeit not when adjusting for age and previous injury in a multivariate model. Our results, based on a greater number of injuries (78 vs. 31) confirm this and suggest that ankle dorsiflexion range of motion may represent a risk factor for hamstring injury. Adequate ankle dorsiflexion mobility is a necessary component for running.[11] Decreased ankle mobility changes the touchdown position of the foot during sprinting, reducing the horizontal force production.[10] As hamstring muscle activity is highly correlated with increased horizontal force production,[34] limited

ankle dorsiflexion mobility might lead to increased work required from the hamstring muscle, predisposing it to injury.

The neuromuscular coordination of the posterior muscle chain has been proposed as a potential risk factor for hamstring injury.[40] Although empirical evidence to support the theory surrounding the function of the posterior kinetic chain is lacking, we might consider how knee extension and ankle dorsiflexion range of motion influence the overall flexibility of the posterior lower limb, and consequently, the conditions necessary for optimal neuromuscular function of the posterior kinetic chain.

Strengths and limitations

While 200 injury cases are needed to detect small to moderate associations between risk factors and injury, 30 to 40 injury cases are needed to detect strong to moderate associations in prospective cohort studies.[6] With 78 cases, this is as yet the largest prospective study investigating flexibility as a potential risk factor for acute hamstring injuries.

These findings suggest that flexibility, measured as hamstring and ankle range of motion, may be involved in the causation of hamstring injury. However, all of the effect sizes observed were small, too small to have any clinical importance.

All tests were performed by highly experienced assessors in a multinational, multilingual clinical setting for professional athletes. Although every effort was made to ensure players understood the test procedure and instructions, it is possible that some players did not comprehend the instructions fully. However, this is representative of current clinical practice, which increases the external validity of the study.

As with every prospective cohort study, we must consider that the once-off baseline test might not necessarily reflect the status of the player at the time of injury. We also acknowledge the homogeneity of our study population of professional male soccer players, which limits the generalizability of these findings to other sports, age groups or female players. Other factors such as training culture and possible prevention strategies within different teams, or climate specific to the Middle East region, could also have influenced the results.

Clinical implications

It is still common practice to include stretching exercises to prevent injury in elite level soccer.[29] Stretching improves the compliance of the musculotendinous unit,[53] and the ability to undergo the stretch-shortening cycle. However, basic science evidence documenting that improved compliance increases the ability to absorb energy is lacking.[42]

Currently there is no intervention study documenting that stretching reduces the risk of hamstring injury .[24,54] Although there are studies showing a reduction in injuries, these were done on with military recruits aiming at reducing overuse injuries.[2,26] While two studies did find an effect on overuse injuries,[2,26] the findings cannot be extrapolated to elite soccer. In fact, a non-randomized intervention study found no effect of a program of warm-up stretching and additional flexibility training on the risk of hamstring injury in elite soccer.[3] Another investigation indicated that stretching might be useful as part of a warm up.[17] However, in this study the warm up program also included running, calisthenics and skill exercises with the ball, and it is unclear which component of the warm up was responsible for the preventative effect.[42]

The passive knee extension and dorsiflexion lunge test cannot be used to predict who may be at risk of injury; there is no suitable cut-off point for either test which can differentiate between injured and uninjured legs. The results display wide overlap between injured and uninjured players (Figures 2 and 3),

as also demonstrated for other risk factors.[7] However, screening has been shown to be valuable in

detecting ongoing musculoskeletal conditions,[8] and flexibility tests may be used to identify underlying

injuries.

CONCLUSION

This study identified deficits in passive hamstring and ankle dorsiflexion range of motion as weak risk

factors for hamstring injury. These findings have little clinical value in predicting future hamstring injury

risk, and test results must therefore be interpreted cautiously in athletic screening.

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