

The functional movement test 9+ is a poor screening test for lower extremity injuries in professional male football players: a 2-year prospective cohort study

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ABSTRACT

Background The 9+ screening battery test consists of 11 tests to assess limitations in functional movement.

Aim To examine the association of the 9+ with lower extremity injuries and to identify a cut-off point to predict injury risk.

Methods Professional male football players in Qatar from 14 teams completed the 9+ at the beginning of the 2013/2014 and 2014/2015 seasons. Time-loss injuries and exposure in training and matches were registered prospectively by club medical staff during these seasons. Univariate and multivariate Cox regression analyses were used to calculate HR and 95% CI. Receiver operating characteristic (ROC) curves were calculated to determine sensitivity and specificity and identify the optimal cut-off point for risk assessment.

Results 362 players completed the 9+ and had injury and exposure registration. There were 526 injuries among 203 players (56.1%) during the two seasons; injuries to the thigh were the most frequent. There was no association between 9+ total score and the risk of lower extremity injuries (HR 1.02, 95% CI 0.99 to 1.05, $p=0.13$), even after adjusting for other risk factors in a multivariate analysis (HR 1.01, 95% CI 0.98 to 1.04, $p=0.37$). ROC curve analysis revealed an area under the curve of 0.48, and there was no cut-off point that distinguished injured from non-injured players.

Conclusion The 9+ was not associated with lower extremity injury, and it was no better than chance for distinguishing between injured and uninjured players. Therefore, the 9+ test cannot be recommended as an injury prediction tool in this population.

INTRODUCTION

Injuries in professional football are common, with injuries to the lower extremity accounting for nearly 90% of all time-loss injuries in senior male professional players.^{1–4} Given the negative impact on player performance,^{5,6} financial cost⁷ and possibly long-term player health,^{8,9} there is interest in using screening tools to identify players at risk for injury with a view to prescribing individualised prevention measures.^{10–12}

Functional movement tests are popular screening tools within professional football as well as other sports,^{8,13} and they all purport to be able to identify players at risk of injury.^{14,15} One such tool is the Nine Plus screening battery (9+).¹⁶ This relatively new tool aims to identify limitations in fundamental movement patterns that predispose athletes to injury.¹⁶ The 9+ consists of six tests

with modified criteria from the Functional Movement Screen (FMS).^{16–18} In addition, Frohm *et al*¹⁶ included five additional tests to fill a gap for tests challenging dynamic trunk flexors, rotation of the spine and knee control and strength.^{16,19} Each movement test is scored on a four-point scale (3–0) with a maximum score of 33 points.

The ability of the 9+ to predict injury is unknown. However, studies using the FMS have shown a significantly higher injury risk among individuals with low FMS scores, using a cut-off score of 14 out of 21 possible points.¹⁵ Still, the sensitivity seems to be low; the receiver operating characteristic (ROC) curve indicates that the overall predictive validity of the FMS was only slightly better than chance.²⁰

We recently demonstrated that there is substantial intraindividual variability in the 9+ total score between two consecutive seasons, irrespective of injury.²¹ We therefore questioned the validity of 9+ as a screening tool to identify the athlete at risk.

The purposes of the present study were to (1) examine the association of the 9+ total score with lower extremity injuries in professional male football players, (2) identify the optimal cut-off point to predict lower extremity injuries and (3) assess the association of the 9+ with the most common injury types in football (hip/groin, thigh, knee, lower leg and ankle injuries).

METHODS

Study design and participants

The present study analysed prospectively collected data from a periodic health evaluation (PHE) of male professional football players in Qatar.²² All players eligible to compete in the Qatar Stars League (QSL), the professional first division of football in Qatar, were invited to participate as they presented for their annual PHE at the Aspetar Orthopaedic and Sports Medicine Hospital in Doha (Qatar) during the 2013/2014 and 2014/2015 seasons. The PHE was performed mainly during the preseason period (66.6%) (July through September), with a small group completing the tests during the early/mid competition phase (23.8%) (October through December) each year and a minor group postseason (9.7%) (end of April through June) in 2014.

The players performed the 9+ test as part of the musculoskeletal component of the PHE. All players who competed for QSL clubs during the 2013 and 2014 season, did not report a current injury or physical complaint limiting training or match play



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at the time of testing and completed the entire 9+ were eligible for analysis. Ethical approval was obtained from the Institutional Review Board, Anti-Doping Lab Qatar. All players signed a written informed consent form at inclusion.

Study procedure

Fourteen experienced sports physiotherapists who all worked at the study institution performed the 9+ testing during the study period. Prior to testing, all physiotherapists had to undergo a 2-day course with the inventors of the 9+,¹⁶ in addition to performing the 9+ regularly in their clinical practice.

The 9+ screening battery was performed as described by Frohm *et al.*^{16 19} The 9+ comprises 11 functional movement exercises to assess stability, mobility and neuromuscular control in the kinetic chain, demonstrating moderate to good inter-rater reliability (intraclass correlation coefficient [ICC] ranging from 0.68 to 0.80).^{16 21} The exercise items are the deep squat, in-line lunge, shoulder mobility, trunk stability push-up, active hip flexion and diagonal lift (all from the FMS with modified criteria) and one-legged squat, deep one-legged squat, drop jump test, seated rotation and straight leg raise. Seven of the 11 tests are assessed bilaterally, looking for asymmetries between left and right. For these tests, the left extremity was tested first, and the lower of the two scores for the left and right side was used for data analysis. Each movement test was scored on a four-point ordinal scale (3–0), with three representing correct completion of the task with no compensatory movements, two correct but with presence of compensatory movement, one incorrect despite compensatory movements and 0 if pain was present. Thus, each player could reach a maximum score of 33 points. A more detailed description of the 9+ movements is provided by Frohm *et al.*^{16 19}

All players performed the tests barefoot, with shorts and a t-shirt, except for the drop jump test. As described by Frohm *et al.*,¹⁹ the players wore their own training shoes for this test. Due to equipment availability, the participants performed the drop-jump test from a 30 cm box, not a 40 cm box height as described by Frohm *et al.*¹⁹ The physiotherapists gave a standardised verbal instruction and showed the player a photo of the starting and finishing position of an optimally performed exercise. Each player performed each test three times, and the maximum score achieved was recorded and used for evaluation of test performance. Verbal corrections were given during the three trials to achieve the most optimal performance. The complete assessment took 20–30 min to complete.

Player characteristics data (ie, age, date of birth, player position) and previous injury history (lower extremity injury, groin, hamstring, quadriceps femoris, knee and ankle injury) were collected from the FIFA precompetition medical assessment form completed during the medical part of the PHE on the same day as the 9+ test.²² A previous lower extremity injury was defined as any time-loss injury occurring within 12 months before the PHE. Height and weight were measured before the 9+ assessment.

Injury registration

Injuries and exposure data were obtained from the Aspetar Injury and Illness Surveillance Program (AIISP). The AIISP includes prospective injury and exposure (minutes of training and match play) recording from all 14 QSL teams.^{4 23} An injury was recorded if the player was unable to fully participate in football training or match play for at least 1 day beyond the day of injury (time-loss injury).^{4 23} The player was considered injured

until declared fit for full participation in training and available for match selection by medical staff.

The team physician (or head physiotherapist when no physician was available) for each team recorded all injuries and individual training and match exposure daily throughout the 2013 and 2014 football season (July–May; 44 weeks). For each injury recorded, the team physician/physiotherapist completed a standardised injury card containing information on the body part injured, injury type and specific diagnosis. In addition, the injury card included questions related to re-injury, overuse or acute injury mechanism (contact or collision), as well as information on whether the injury occurred during training or match.²³ Injury severity was determined by the number of days absent from matches or training sessions due to injury and was classified as mild (1–3 days), minor (4–7 days), moderate (8–28 days) or severe (>28 days).²³ Injury and exposure data were requested monthly by the study group, and the accuracy was checked regularly and clarified with the team doctor if needed.

Statistical analyses

Data were analysed with IBM SPSS statistics, V.21.0. Descriptive data are presented as the mean $\pm$ SD unless otherwise stated. Individual exposure data were calculated as sum of the total number of hours of training and match play from the individual player's screening date to the end of the season for each season or date until the first injury. To examine the relationship between any lower extremity injury (yes/no) with 9+ total score and other potential risk factors (anthropometric data, player position, previous injury and season), we used Cox regression analysis (STATA V.11.0) with each player as the unit of analysis. The 9+ test score for each season was used as a predictor for injury (yes/no) for that respective season. To account for the repeated measures performed over the two seasons, as well as the fact that not every participant had the same number of measurements (ie, some participants would have test results for both seasons, some for only one season), the player ID was used to cluster the related observations when estimating the Cox model.

Similar and separate analyses were performed for assessing relationship between 9+ total score and injuries to the hip/groin, thigh, knee, lower leg and ankle. Injuries to the foot/toe were excluded from these analyses because of the low number of such injuries (n=19).

The HRs presented with 95% CIs are per one unit of change in the independent continuous risk factor (9+ scores, anthropometric data). For categorical variables (season, player position and previous injury history), HR with 95% CIs represents change in risk when compared with the reference category. After the univariate analyses, all factors with a p value of <0.20 were investigated further in a multivariate model. A p value of <0.05 was considered as statistically significant.

ROC curves were calculated to describe the sensitivity and specificity of the 9+ test for each dependent variable. The area under the curve (AUC) indicates how well the 9+ total score would discriminate between injured and uninjured players and was interpreted as excellent (1.00–0.90), good (0.90–0.80), fair (0.80–0.70), poor (0.70–0.60) or fail (<0.60).^{24 25} The ROC curve was also used to determine an optimal cut-off point for identifying high- and low-risk players for lower extremity injuries. Identified cut-offs with maximum sensitivity and specificity were further used as a factor in the Cox regression analysis as described above to evaluate differences in injury risk. We also calculated the likelihood ratio (LR). LR is a combination of sensitivity and specificity values reported as a ratio used to

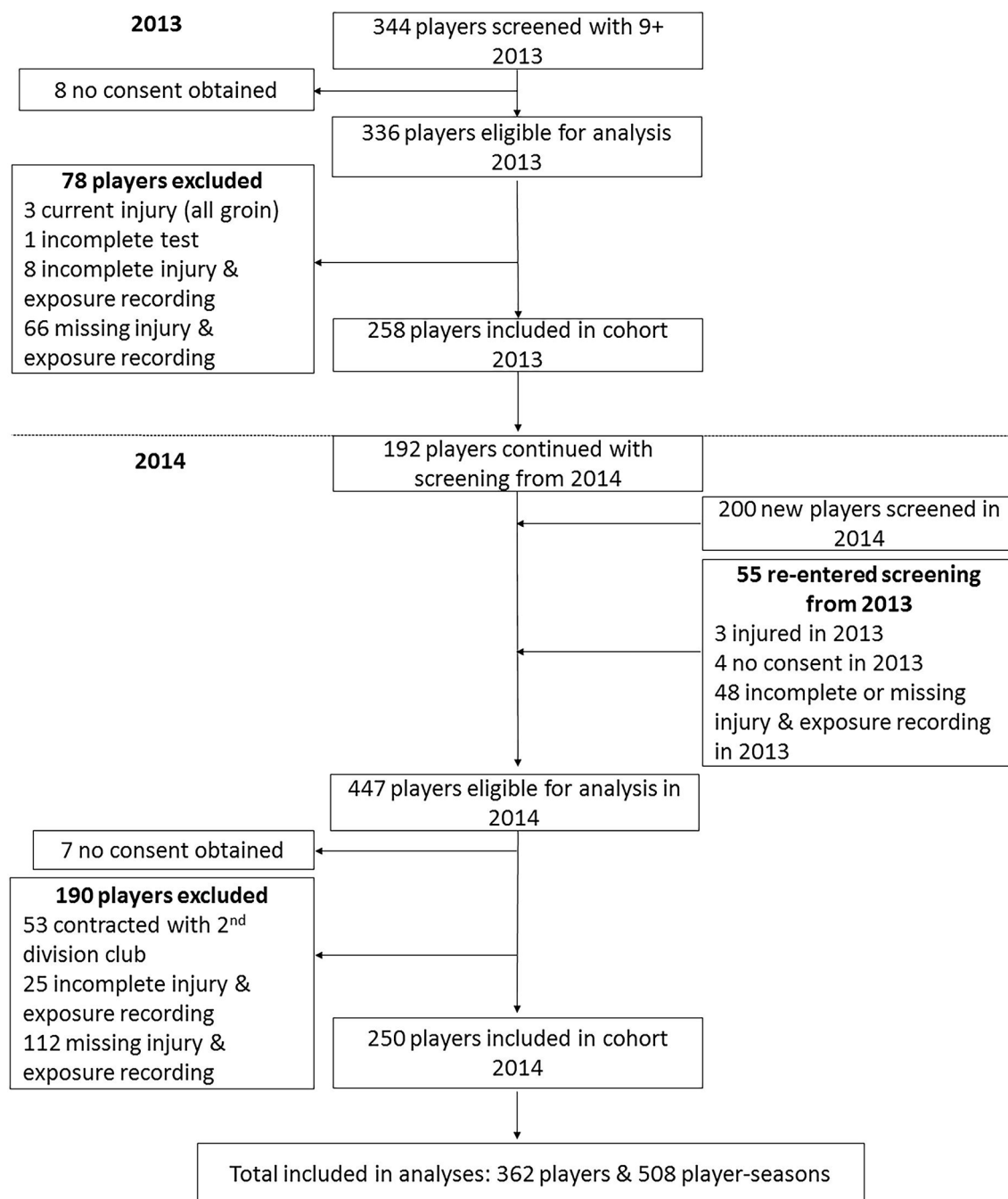


Figure 1 Flow chart demonstrating the movement of players and repeated 9+ between the two seasons.

determine whether a test result usefully changes the probability that a condition exists.²⁶

RESULTS

Participants

The inclusion process is shown in figure 1. The final sample included 362 players who provided complete data sets for both 9+ and the prospective injury and exposure registration (age 26.0 ± 4.7 years, height 177 ± 7 cm, weight 72 ± 9 kg, body mass index 23.0 ± 1.9 kg/m²). The players included participated in a total of 508 player-seasons ($n=216$ played one season, $n=146$ two seasons) and represented 42 nationalities, the majority from the Middle East (65.2%). By ethnicity, 54.7% were Arab, 30.7% black, 5.2% Caucasian, 1.7% East Asian, 5.5%

Persian and 2.2% other. A history of previous lower extremity injury was reported by 34.5% of the players. Player positions included 40 goalkeepers (11%), 126 (34.8%) defenders, 130 (35.9%) midfielders and 66 (18.2%) forwards. The mean 9+ total score of the players ($n=362$) was 22.5 ± 4.0 , ranging from 13 to 31.

Injury and exposure characteristics

In total, 203 of the 362 (56.1%) players sustained at least one lower extremity injury during the two seasons, and a total of 526 lower extremity injuries were reported. During the 2013 season, 143 of the 258 players included sustained at least one lower extremity injury, while 140 of the 250 players included during the 2014 season experienced at least one lower extremity

Table 1 Characteristics of lower extremity injuries (n=526) related to location and injury type

Injury type (body part injured)	Muscle strain	Muscle cramps/spasm	Sprain/ligament injury	Contusions	Meniscus/cartilage lesion	Tendon injury	Fracture	Other	Total (%)
Hip/groin	69	19	–	2	–	17	–	9	116 (22.0)
Thigh	101	32	–	18	–	9	–	1	161 (30.6)
Knee	–	–	30	16	14	18	–	7	85 (16.2)
Lower leg	23	13	–	8	–	12	3	4	63 (12.0)
Ankle	–	–	55	19	–	1	2	5	82 (15.6)
Foot/toe	–	–	2	7	–	–	6	4	19 (3.6)
Total (%)	193 (36.7)	64 (12.2)	87 (16.5)	70 (13.3)	14 (2.7)	57 (10.8)	11 (2.1)	30 (5.7)	526 (100)

injury. A muscle strain to the thigh was the most frequent injury type (table 1). More than half of the injuries occurred during training (52.7%, n=277), and the majority of the injuries were moderate (n=207, 39.4%), leading to an absence from football training and match play for 8–28 days.

The mean player exposure was 214 ± 93 hours per season, 189 ± 88 hours of training and 25 ± 16 hours of match play.

9+ and lower extremity injuries

The results of the univariate analyses are shown in table 2. As shown in figure 2, there was substantial overlap in the frequency distribution of the 9+ total score between the injured and uninjured groups. Consequently, there was no association between 9+ total score and the risk of sustaining a lower extremity injury (HR 1.02, 95% CI 0.99 to 1.05, p=0.13). Also, the outcome was the same when hip/groin, thigh, knee, lower leg and ankle injuries were used as the dependent variable in separate univariate analyses (table 3).

Age, player position and season were the only factors associated with an increased risk of lower extremity injury and remained significant in the multivariate model. The 9+ total score remained not significant even after adjusting for other candidate risk factors (table 4).

We also performed similar and separate subanalyses assessing the relationship between 9+ total score and overuse (n=161) and acute (n=201) injuries, respectively. There was

no association between 9+ total score and the risk of overuse injuries (HR 1.003, 95% CI 0.97 to 1.04, p=0.85) nor with acute injuries (HR 1.02, 95% CI 0.99 to 1.06, p=0.18) (see online supplementary tables A1 and A2). The outcome remained the same when adjusting for other candidate risk factors in a multivariate analysis (table 4).

Risk factors for hip/groin injuries

A total of 116 hip/groin injuries were recorded in 92 players, mainly adductor strain (n=55, 47.4%). Anthropometric data, age, previous groin injury and player position were not associated with an increased risk of hip/groin injuries (see online supplementary table A3). Since none of the candidate risk factors had a p value of <0.20 in the univariate analysis, no multivariate analysis was performed.

Risk factors for thigh injury

Of the 161 thigh injuries recorded in 120 players, 105 (65.2%) affected the hamstring muscles. Univariate analysis identified only age as a candidate risk factor for a thigh injury (see online supplementary table A4); however, this factor did not remain significant in the multivariate model (table 4).

Risk factors for knee injury

Sixty-nine players sustained at least one knee injury, and 85 injuries were recorded, of which eight were ACL injuries. A

Table 2 Univariate analysis comparing player-seasons with and without lower extremity injury (n=508 player-seasons)

	n	Injured (n=283), mean±SD	Uninjured (n=225), mean±SD	HR	95% CI	p-Value
9+ total score	508	22.9±3.8	22.7±4.1	1.02	0.99 to 1.05	0.13
Age, years	508	27.0±4.8	25.8±4.7	1.04	1.01 to 1.06	0.005
Height, cm	508	177±7	176±7	1.005	0.99 to 1.02	0.59
Weight, kg	508	73±9	72±9	1.01	0.995 to 1.02	0.23
BMI, kg/m ²	508	23.1±2.0	23.0±1.9	1.04	0.98 to 1.10	0.18
Previous lower extremity injury, * n (%)	492	97 (35.0)	76 (35.3)	1.05	0.81 to 1.36	0.72
Player position, n (%)	508					
Goalkeeper†		23 (8.1)	33 (14.7)	1.0	1.0	
Defender		100 (35.3)	76 (33.8)	1.63	1.07 to 2.48	0.02
Midfielder		104 (36.7)	87 (38.7)	1.59	1.05 to 2.42	0.03
Forward		56 (19.8)	29 (12.9)	2.05	1.31 to 3.20	0.002
Season, n (%)	508					
Season 1†		143 (50.5)	115 (51.1)	1.0	1.0	
Season 2		140 (49.5)	110 (48.9)	1.31	1.03 to 1.65	0.02

Data are presented as mean±SD for injured versus uninjured players. HRs per one unit of change for continuous variables (ie, 9+ score) and change in risk when compared with the reference category for categorical variables are presented with 95% CIs and p values from Cox regression analysis accounting for clustering factors (player ID) and using player as the unit of analysis.

*History of previous injury refers to any lower extremity injury occurring within 12 months prior to the 9+ test.

†Reference group in analysis.

BMI, body mass index.

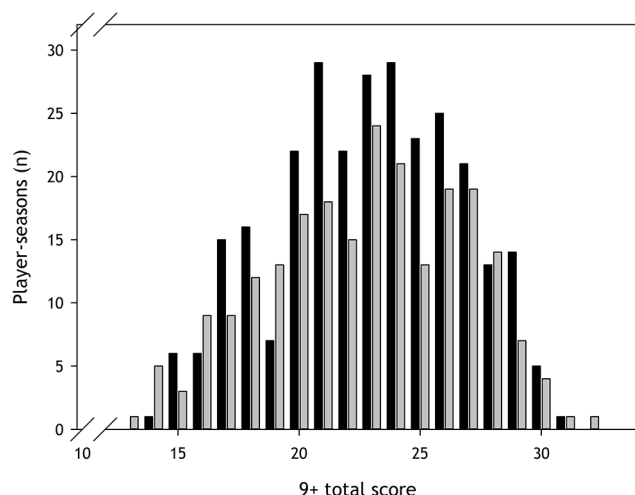


Figure 2 Distribution of 9+ score in the injured (n=283) versus uninjured groups (n=225). Black bars represent the injured group; grey bars, the uninjured group.

previous knee ligament injury and playing in season two were the only factors associated with an increased risk of knee injury (see online supplementary table A5). In the multivariate model, only a previous knee ligament injury was found to increase the risk of a knee injury (table 4).

Risk factors for lower leg

Of the 63 lower leg injuries in 52 players, age and playing in season 2 were the only factors associated with lower leg injuries (see online supplementary table A6); season was also significant in the multivariate analysis (table 4).

Risk factors for ankle injury

Being a defender was the only factor associated with 82 ankle injuries in 75 players (see online supplementary table A7) and remained significant in the multivariate model (table 4).

9+ test characteristic for lower extremity injuries

Analysis of ROC curves revealed an AUC of 0.48 (95% CI 0.43 to 0.54, $p=0.53$) for lower extremity injuries, indicating a failed combined sensitivity and specificity of the 9+ total score to predict lower extremity injury. The outcome was the same whether hip/groin injuries (AUC 0.53, 0.47 to 0.60, $p=0.36$), thigh injuries (AUC 0.51, 0.45 to 0.57, $p=0.68$), knee injuries (AUC 0.46, 0.39 to 0.52, $p=0.27$), lower leg (AUC 0.45, 0.37 to 0.54, $p=0.25$), ankle injuries (AUC 0.47, 0.40 to 0.54, $p=0.36$), overuse injuries (AUC 0.51, 0.45 to 0.56, $p=0.82$) or acute

Table 3 Univariate analysis for the relationship between 9+ total score and each binary outcome-dependent injury variable (n=508 player-seasons)

Injury location	HR	95% CI	p Value
Hip/groin	0.98	0.93 to 1.03	0.52
Thigh	0.99	0.95 to 1.04	0.84
Knee	1.05	0.99 to 1.10	0.09
Lower leg	1.05	0.98 to 1.12	0.15
Ankle	1.04	0.98 to 1.10	0.21

HR per one unit of change in 9+ scores is presented with 95% CIs and p values from Cox regression analysis accounting for clustering factors (player ID) and using player as the unit of analysis.

Table 4 Multivariate analyses for 9+ total score including all candidate risk factors achieving $p<0.20$ in the univariate analyses for all dependent variables

	HR	95% CI	p Value
<i>Lower extremity</i>			
9+ total score	1.01	0.98 to 1.04	0.37
Age	1.03	1.01 to 1.06	0.01
BMI	1.04	0.97 to 1.10	0.25
<i>Player position*</i>			
Defender	1.79	1.16 to 2.77	0.01
Midfielder	1.80	1.17 to 2.76	0.01
Forward	2.28	1.44 to 3.61	<0.001
Season†	1.30	1.02 to 1.64	0.03
<i>Thigh</i>			
9+ total score	0.98	0.93 to 1.03	0.39
Age	1.04	0.998 to 1.07	0.06
Previous QF injuries	1.86	0.65 to 5.31	0.25
<i>Player position*</i>			
Defender	1.65	0.76 to 3.60	0.20
Midfielder	1.56	0.72 to 3.40	0.26
Forward	1.89	0.82 to 4.37	0.14
Season†	1.39	0.96 to 2.01	0.08
<i>Knee</i>			
9+ total score	1.03	0.97 to 1.09	0.34
BMI	1.11	0.96 to 1.28	0.16
Previous knee injury	2.15	1.10 to 4.21	0.02
Season†	1.44	0.86 to 2.38	0.16
<i>Lower leg</i>			
9+ total score	1.02	0.95 to 1.10	0.51
Age	1.06	0.999 to 1.13	0.05
Season†	2.07	1.21 to 3.54	0.01
<i>Ankle</i>			
9+ total score	1.04	0.98 to 1.10	0.21
<i>Player position*</i>			
Defender	2.82	1.05 to 7.58	0.04
Midfielder	2.42	0.90 to 6.51	0.08
Forward	1.34	0.42 to 4.24	0.62
<i>Overuse</i>			
9+ total score	1.005	0.97 to 1.04	0.81
<i>Player position*</i>			
Defender	2.25	1.15 to 4.42	0.02
Midfielder	1.68	0.86 to 3.26	0.13
Forward	2.71	1.35 to 5.46	0.005
<i>Acute</i>			
9+ total score	1.005	0.97 to 1.04	0.77
Age	1.04	1.01 to 1.07	0.01
<i>Player position*</i>			
Defender	1.37	0.86 to 2.19	0.19
Midfielder	1.58	0.99 to 2.53	0.06
Forward	1.59	0.96 to 2.63	0.07
Season†	1.69	1.26 to 2.25	<0.001

HRs per one unit of change for continuous variables (ie, 9+ score) and change in risk when compared with the reference category for categorical variables are presented with 95% CIs and p values from Cox regression analysis accounting for clustering factors (player ID) and using player as the unit of analysis.

Since none of the candidate risk factors had a p value of <0.20 in the univariate analysis for hip/groin injuries, no multivariate analysis was performed.

*Reference category for player position: goalkeeper.

†Reference category: season 1 (2013).

BMI, body mass index; QF, quadriceps femoris.

Table 5 Univariate analysis 9+ total score and lower extremity injury risk using a cut-off ≤ 23 derived from the ROC curve analysis

9+ score	Injured (n=283),	Uninjured (n=225),	HR	95 % CI	p Value
≤ 23	152	126	0.84	0.66 to 1.07	0.17
> 23	131	99	1.0		

HR per one unit of change in 9+ scores is presented with 95% CIs and p values from Cox regression analysis accounting for clustering factors (player ID) and using player as the unit of analysis.

injuries (AUC 0.48, 0.43 to 0.54, $p=0.57$) were used as main outcomes.

Although the intention of the study was to determine the optimal cut-off point for lower extremity injury risk screening, the ROC curve analysis could not provide a point that maximised specificity and sensitivity. However, derived from the ROC curve, we examined a cut-off of ≤ 23 points, which provided the best maximum sensitivity and specificity as a predictor for lower extremity injury. The corresponding sensitivity and specificity were 0.54 (95% CI 0.48 to 0.60) and 0.44 (95% CI 0.37 to 0.51), respectively, with a positive LR (LR+) of 0.96 (95% CI 0.82 to 1.12) and negative LR (LR-) of 1.05 (95% CI 0.92 to 1.21). There was no increased risk of lower extremity injury for those who scored ≤ 23 points compared with those who scored > 23 points (table 5). The same results were found in the multivariate model when adjusting for all candidate risk factors listed in table 2 (HR 0.90, 95% CI 0.71 to 1.15, $p=0.41$ compared with the > 23).

DISCUSSION

In this large prospective cohort study on professional football players, the 9+ total score was consistently not associated with an increased risk of lower extremity injury, even after adjusting for other potential risk factors in a multivariate analysis. There was considerable overlap in 9+ scores between injured and uninjured players, and ROC analyses revealed no cut-off point to identify the at-risk player, as shown in figure 2, indicating a complete failure in discriminating between injured and uninjured players based on the 9+ total score.

9+ test and predicting injury in professional male football players

The lack of association between 9+ total score and risk of lower extremity injury argues against the use of the 9+ test as an injury prediction tool.²⁷ Although a direct comparison of the test batteries and study methodologies cannot be made, comparable findings were reported in recent studies on the FMS among football players.^{28–32} Two recent meta analysis on the FMS drew similar conclusions that the FMS does not allow clinicians to predict injuries.^{20 33}

We also found no association between 9+ total score and hip/groin, thigh, knee, lower leg and ankle injuries. Compared with the FMS, the 9+ comprises three additional tests that assess knee control and strength. Excessive knee valgus motion is a key feature of the mechanisms of ACL injury, particularly in the female athlete population.^{34–36} The added tests are frequently used in return-to-sport decision making, to measure treatment response and as screening tools for knee injuries (ACL and patellofemoral pain); however, their usefulness for injury prediction is debated.^{27 37–39} Given this, and the relatively low number of knee injuries and poor reliability identified for these three

tests in our population,²¹ our analyses should be interpreted with caution.

It is argued that decreased movement quality (as assessed on the 9+ and FMS) resulting from decreased range of motion and reduced neuromuscular control increases the risk of overuse injury.^{40 41} However, we found no association between 9+ total score and overuse injuries nor with acute injuries. Comparable findings have been reported in studies on FMS among college athletes.^{42 43}

For a screening test to predict sports injury, in addition to demonstrating an association with injury, it also needs to identify the athlete at high risk of injury compared with those who are not.²⁷ The ROC curve analysis revealed an AUC of only 0.48, indicating that the 9+ test is no better than chance in predicting lower extremity injuries. This inability to predict injury is substantiated by the complete overlap and similar distributions of the 9+ total scores for the injured and uninjured groups; there is no cut-off point we could place on the horizontal (9+ score) axis which would allow us to separate injured and uninjured players. Comparably low AUCs have also been reported in other studies on the FMS.^{20 28 32 44} Examining specific injury subgroups, we also observed a similarly low AUC for hip/groin, thigh, knee, lower leg and ankle injuries. Therefore, the 9+ test has poor accuracy as an injury prediction tool for any of these most common injury types in football.

Frohm *et al*¹⁶ in their reliability study of the 9+ on elite football players hypothesised that a 9+ total score below 67% (22 points) was the threshold at which players were predisposed to injury. Our ROC curve analysis could not identify a clinically useful cut-off point. A cut-off of ≤ 23 ($\leq 69.7\%$ of the possible maximum of 33 points) provided the best fit for sensitivity and specificity, comparable to the recently debated cut-off point of 67% (≤ 14 points of possible 21) of the FMS.^{11 14 15 20} Nevertheless, this cut-off provided a sensitivity and specificity of 0.54 and 0.44, respectively, demonstrating that the discriminatory ability is only slightly above chance.⁴⁵ Therefore, it is not surprising that there was no increased risk of lower extremity injury for those who scored ≤ 23 compared with those who scored > 23 . The LR+ of 0.96 further demonstrates that when the test is positive, the athlete is slightly less likely to suffer an injury in the subsequent season. Although the LR+ 95% CI crossed one (0.82 to 1.12), the post-test probability of an injury is altered to an insignificant degree, if at all, by the 9+ test. Comparable findings were reported in a recent meta-analysis on the FMS.²⁰

Clinical implications

Functional movement tests, including the 9+, are growing in popularity as an injury screening tool putatively as they provide clinicians with information about an individual's risk of injury.^{8 15} The validity of the FMS as an injury prediction tool has been scrutinised recently and with conflicting results. Wright *et al*¹¹ in an editorial concluded that because of this inconsistency in findings and low accuracy (sensitivity and LR-), the FMS cannot confidently be used as an injury prediction tool. The 9+ appears to exhibit similar properties. Based on our results, the 9+ total score should not be used to screen the athlete at risk for lower extremity injuries. Although our results show that using the 9+ total score to predict injury is no better than flipping a coin, this does not necessarily mean that clinicians should stop using functional movement tests. They may still hold value to detect deficits or asymmetries that could require further assessment or treatment.²²

Methodological considerations

The large number of participants and injured players represents a strength of the current study. Bahr and Holme⁴⁶ suggested that 30–40 injury cases would be needed to detect strong to moderate associations and that 200 injury cases are needed to find small to moderate associations. Also, the organisation of sports medicine care in Qatar with all club medical doctors and physical therapists being part of the centrally regulated National Sports Medicine Programme (NSMP) allowed for standardisation of injury and exposure recording. The present study was performed in a professional athlete setting, using multiple testers. This provides good generalisability but might have also adversely influenced the inter-tester reliability. We found only moderate reliability between our testers in a recent study on the inter-season variability of the 9+ test.²¹

Limitations to the present study include that the team physician or physiotherapist responsible for the injury and exposure reporting was not blinded to the 9+ test score. Also, we did not record if any prevention interventions occurred in the teams based on the player's 9+ test score. Given the high number of injuries recorded during the study period (n=526 injuries), we believe that it represents a low risk of bias.

Finally, we acknowledge that as our study included a group of male professional football players, this limits the generalisability of the findings to other sports, age groups and women. This study should be repeated in other athlete populations, including female athletes, other age groups and athletes at lower performance levels.²⁷

SUMMARY AND CONCLUSION

This study could not identify any association between 9+ total score and risk of lower extremity injury in professional male football players, even after adjusting for other risk factors. The 9+ total score was no better than chance for distinguishing between injured and uninjured players. Therefore, the 9+ test cannot be recommended as an injury prediction tool in this population.

What are the findings?

- The 9+ total score was not associated with the risk of lower extremity injuries or any of the most common injury types in professional male football players (hip/groin, thigh, knee, lower leg, ankle injuries).
- The 9+ total score was no better than chance for distinguishing players who would sustain an injury and those who would not.

How might it impact on clinical practice in the future?

- The 9+ test is not recommended as an injury prediction tool in male professional football players.

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the final revision of the article. KMK, ST, TB, CE and JLT interpreted the data, revised the article and approved the final revision of the article.

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