BMJ Open Sport & Exercise Medicine

Preseason intrinsic risk factors—associated odds estimate the exposure to proximal lower limb injury throughout the season among professional football players

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To cite: Liporaci RF, Saad MC, Bevilaqua-Grossi D, *et al*. Preseason intrinsic risk factors—associated odds estimate the exposure to proximal lower limb injury throughout the season among professional football players. *BMJ Open Sport & Exercise Medicine* 2018;**4**:e000334. doi:10.1136/bmjsem-2017-000334

Accepted 30 March 2018

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ABSTRACT

Background/aim Football players frequently face the occurrence of non-contact musculoskeletal injuries. The purpose of the study was to verify whether the evaluation of combined risk factors could produce a score system to determine the probability of injury in football players during the Brazilian football season.

Methods Sixty-two male professional soccer players recruited from the first and second division soccer teams, with ages between 18 and 36 years. Functional performance evaluations were carried out at the beginning of the preseason which included strength and jumping tests, history of injuries and characteristics of athletes.

Results and conclusions The results were grouped and a score/monogram was constructed.

What are the new findings?

- Perhaps the great thing about the work would be the creation of a tool that can actually predict the risk of injury and so we can act in a preventive way with the athletes.
- Functional assessments are critical to rehabilitation and prevent injuries.

How might it impact on clinical practice in the future?

- With this type of evaluation and with this tool of 'injury prevention' we can act in a preventive way and avoid that athletes develop any type of injury and have long periods in rehabilitation since it is a sport that moves millions of dollars, and these athletes, when injured, imply large financial losses to the clubs.
- Rehabilitation and preventive programmes should focus on the deficits presented in the functional assessments results.

Football is one of the most popular sports worldwide. Apart from the 260 million players registered in football clubs around the globe, hundreds of millions of people play football without becoming a member of a national or an international football association.[1] Football players are susceptible to musculoskeletal injuries. Predictive intrinsic factors of proximal lower limb injuries include asymmetries in muscle strength,[2–4] flexibility[5–7] and proprioception,[8 9] as well as joint instability,[10] anatomical and anthropometric asymmetries,[11 12] age[2 13–16] and previous injury.[10 14–16] Other factors that may influence the incidence of injuries in football are the level of play, musculoskeletal load (ie, number of training activities and matches) and the training patterns.

The risk of injuries during matches is higher in high-level players compared with low-level players.[13 17 18] On the other hand, during training the outcome appears to be the opposite.[13 17] Several authors have investigated the frequency of injuries in elite football,[19–21] and it is clear that the incidence of injuries among elite players is much higher, with 65%[20] to 91%[19] of the players incurring an injury during one season.

Professional football requires a high level of financial investment in structure and maintenance[22 23] and financial losses were associated with high incidence of injuries.[22–25] Preventive evaluations to reduce injuries have received attention from sports physical therapists.[26–29]

However, the evaluation of only strength parameters makes weak or unfounded the premise that this type of evaluation will predict the risk of hamstrings and anterior cruciate ligament injuries,[28 29] for example. Thus, other parameters such as age, body mass and playing position should be considered.[29] Other evaluation parameters such as the functional movement screen (FMS),[30 31] modified FMS,[32] among others, are also used as tools for evaluation and prediction of injury, but with unsatisfactory results.[32] According to Bahr,[27] in a recent review, screening tests may never be able to predict lesions but will help us to classify individuals at increased risk and so we could intervene preventively. In a disease, screening tests aim to start treatment as soon as possible. In sports injury prevention, the objective is early intervention to minimise the risk factor before injury occurs.[27]

A comprehensive assessment of factors associated with the risk of lower limb musculoskeletal disorders throughout the season should include muscle performance tests, premorbid injuries, training and match habits, as well as individual characteristics, such as age and limb dominance. This emphasises the importance of accounting for risk exposure when estimating the occurrence of injury in football. The high intensity and the tight schedule of training sessions and matches are factors that may contribute to the high incidence of injury among the *elite* soccer players.[33]

The evaluation of combined risk factors described in the literature could facilitate the screening of athletes at risk of injury and improve the approach and monitoring throughout the season. Based on our previous study, we evaluated the influence of risk factors taking into account professional assessment, physical assessment and functional tests of each individual. The present study aimed to verify whether the evaluation of combined risk factors could produce a score system to determine the probability of injury in football players during the Brazilian football season.

METHODS

Sixty-two male professional soccer players, with ages between 18 and 36 years, participated in the present study. The athletes were recruited from the first and second division soccer teams of the largest Brazilian State Championship organised by the Brazilian Football Confederation (CBF), affiliated to FIFA.

Criteria for inclusion

All of the participants were registered at CBF; no musculoskeletal injury in the knee or thigh at the time of evaluation; and with scores ≥84 in functional performance questionnaires.

All subjects were informed about the objectives of the study and agreed to participate by providing their free and informed consent.

Evaluations

The functional performance evaluations were carried out as described below at the beginning of the preseason of the championships in the years 2013, 2014 and 2015. The training period before the start of the first official match of the competition was also included. The evaluations were conducted by trained physiotherapists.

History of injuries and previous professional activities

The data collected for the study referred only to the injuries in the knees and thighs that occurred in the last two years. Data on previous moderate or severe injuries in the knee–thigh complex that required the player to miss participation time of at least three matches, and 15–25 days of absence from practice, were recorded to provide current evidence on significant changes. The history of the athletes' prior professional experience was also recorded for comparison with their current performance, with or without reports of musculoskeletal disorders and/or changes in the tests.

Lower extremity functional tests

The functional tasks used in this investigation were the single-hop test (SHT) and the cross-over hop for distance test (COHDT) with sensitivity (SHT: 53.0, COHDT: 88.0; 95% CI) and specificity (SHT: 72.0, COHDT: 47.0; 95% CI) already described by Logerstedt.[34] These tests were applied to determine cut-off scores. Next, the athletes were placed on the kinetic dynamometer for the measurement of several variables related to muscular performance.

The SHT and COHDT, as described by Noyes *et al*,[35] were used to assess the symmetry of the lower limbs during horizontal hops with displacement postligament injuries. Maximum distance was measured from the posterior heel of the last hop.[35]

Three collections were made from each test, and the mean value was calculated for analysis. When the difference in symmetry between the limbs was <20%, the athlete was considered fit to perform the muscle performance tests. If the asymmetry between the limbs was >20%, the athlete was referred to CT exam and to a more detailed orthopaedic evaluation to investigate the possibility of a more acute lower limb musculoskeletal injury.

Isokinetic evaluation

Muscle activity of the players was evaluated using an isokinetic dynamometer Biodex System V.4 (Biodex Medical Systems, New York, USA) with sensitivity (45.5; 95% CI) and specificity (97.0; 95% CI) already described by Almosnino *et al*.[36]

Participants performed a warm-up exercise on an ergometric bicycle for 10 min. Each player was given a brief explanation to become familiar with the tasks. Pain intensity was assessed before and after the test using a visual analogue scale. This instrument is a semiobjective score system used to quantify the intensity of pain.[37]

A test was performed for each knee with the angle velocity of 60°/s (six repetitions of flexion and extension of the knee during the concentric phase with a rest interval of 90 s between sets). The evaluators encouraged the athlete during the entire test with verbal commands.

Isokinetic parameters with their respective values were obtained using a computer program to determine the peak torque (PT) and hamstrings/quadriceps ratio (H/Q ratio).

Characteristics of the athlete

Some characteristics that may be related to physical quality and effective performance of the athlete during matches were analysed to determine the relationship between the performance in clinical trials and the injury incidence rate throughout the season. These characteristics included age,[38] body mass index (BMI),[39] lower limb dominance, defined as the preferred leg used to kick the ball[40] and position on the field: goalkeeper, defender, full-back, midfielder or centre-forward.[41]

Season injury follow-up

The thigh and knee complex injuries were diagnosed by the medical team from the soccer club and tabulated. Injuries to knee joint cartilage, meniscus and/or other ligaments that caused the player to miss training sessions or matches were computed together and separately. The injuries in other portions of the leg were not considered for this study.

A time-loss injury was defined by the FIFA Medical Assessment and Research Centre as 'an injury that resulted in a player being unable to take a full part in future training or match play'.[42] About 80% of injuries occur without physical contact or by the influence of external forces to the body. The high demand the musculoskeletal system of the lower limb is submitted to refers to the psychological factors.[42]

Statistical analysis

The qualitative variables were summarised as frequencies and expressed in percentages. The quantitative variables were described as measures of central tendency and dispersion, according to their distribution.

To define the exposure to injury, the athletes were classified as those with 'no muscle imbalance' or those 'with muscle imbalance', according to the relationship considered potentially predictive of injury: H/Q ratio >64% or <55% and differences >10% in peak of torque of the knee flexors and extensors between the limbs were also considered.

The incidence of injuries was defined as the number of new musculoskeletal injuries that occurred in each muscle groups or structures comprising the ligament complex and meniscus during the official championship matches subsequent to the evaluation (from February to May).

To estimate the raw OR adjusted for covariate of interest to detect risk factors for injury, a logistic regression model with random effects belonging to the class of generalised estimating equations models was proposed. This model represents the linear relationship between the response variable and the covariates.[43]

Scores for the risk of injury derived from the association between risk factors

Following the definition of the OR for each variable evaluated independently for the risk of injury during the preseason, a nomogram or score was constructed to calculate the injury predictions for each athlete and to give a total point score. For each of the variables, the corresponding number of points was read from the top scale. These were then summed to give a total point score, which was then readily translated into a probability of risk for the lower limb injury during the championship matches.

The nomogram outperforms the traditionally used staging systems because it considers multiple commonly available prognostic variables simultaneously, including the identification, calibration and stratification of risk factors according to a particular outcome. The nomogram provides a simple graphical representation of sophisticated statistical prediction models and has been accepted as a reliable tool for predicting clinical events and also for using in scientific studies.[44] The information collected during the preseason was integrated in the nomogram. Consequently, the outcomes could be analysed more effectively to help guide prevention and intervention strategies.

Combining the risk factors for injuries in the proximal portion of the lower limbs

Blanch and Gabbet[45] evaluated the relationship between the current weekly workloads the athletes were exposed to and the mean workload of the four previous weeks and established an equation to measure the probability of developing an injury at a later date. These findings have encouraged us to create a similar, consistent and easy-to-use instrument to gather a combination of risk factors, considering that a single risk factor would not be enough to predict injuries.

The present study was based on a previous study carried out by our research group. The risk of injury in Brazilian football players during the season was evaluated using preseason data collected from three constructs:

1. *Professional profile,* which included his professional history, current team and playing position;
2. *Physical profile data,* which consisted of BMI, age (the athletes were divided into three age groups: group A, ages between 18 and 24 years and 11 months; group B, ages between 25 and 29 years and 11 months; and group C, athletes over 30 years) and lower limb dominance.
3. *Functional profile,* which consisted of functional performance data from the lower limb. The isokinetic variables analysed were H/Q ratio and PT of the knee extensor and flexor muscles, SHT and COHDT.

According to our preliminary findings on risk of injury and the evaluation of each item referred to in the functional performance profile, we found a strong relationship between the incidence of injuries throughout the season in athletes who showed an H/Q ratio <55% or >64%. This was an interesting finding, considering that the use of H/Q ratio cut-off for lower limb muscle imbalance was set at <0.6 (60%),[46] suggested by previous studies, still retained a large number of 'false negatives' for the athletes who have suffered injury, and with H/Q ratio of 60%.

The range between 55% and 64% in H/Q ratio proved to be more realistic in determining athletes at risk of injury that were out of this range. Therefore, the lower and higher values were used as references to obtain the equation score of the H/Q ratio in our equation. The PT values of flexor and extensor muscles were scored based on our previous findings of high risk of injury observed in the lower limb of athletes with PT values of flexor or extensor muscles of at least 10% less than those of the contralateral leg. In other words, when the difference of the PT values of flexor or extensor muscles was >10%, the score was different for the weakest lower limb compared with the limb with higher PT values.

The advantages of using a nomogram and its score system in football

Based on a parallel observational study to establish the risk factors, our hypothesis was that, with the use of a particular statistic methodology, a strong agreement could be established to score each variable, whether present or not, according to its relevance on the observation of individual risks. Thus, the combination of risk factors would produce a score for the level of exposure to predict future injuries. Even the variables with no significant relevance in the original study, although based on reports in the literature with correlation indexes for future injuries, obtained adequate scores for their findings. A score was obtained for each item of the profiles and for the strength ratio using a combined evaluation to obtain the score for probability of injury. The concordance index for the nomogram was 84%,[44] which was enough to confirm the correlation between the score and the probability of injury. Figure 1 shows the nomogram and the variables, and table 1 shows the scores. Table 1 also shows the values for each score and the final score obtained for each lower limb and the probability of injury.

The complexity of determining multiple risk factors and reflecting on their interactions in the athlete's body to estimate which player deserves more attention and preventive care has hindered the introduction and choice of preventive protocols and athletes in need of extra support to meet the physical demands during the preseason.

The failure of the proposed preventive approach was the result of the need to optimise training performances in a short period of time. Therefore, those prevention protocols based on prior studies should be adapted to the original to reduce compliance and, consequently, influence the prevention effectiveness. Coaches, athletic trainers and physiotherapists with low compliance to carry out the previously proposed protocols that have produced positive outcomes[47] showed the need for instruments to facilitate the tracking and quantification of athletes at risk of injury. The use of a nomogram that combines risk factor variables helps understand such risks and contributes to the work of sports medicine.

The use of a nomogram for football players

The nomogram proposed should estimate the score for each lower limb to establish the probability of injury based on the association of variables obtained from the athlete through the score defined for each answer and described in table 1.

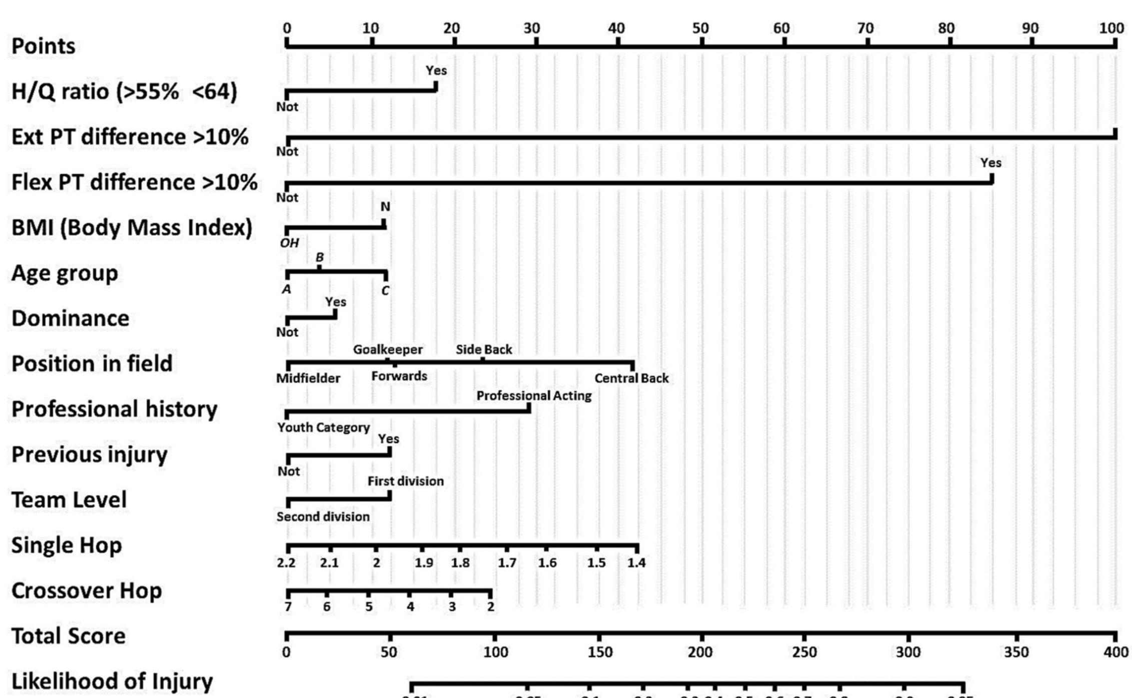

Figure 1 Nomogram, the variables and the scores. BMI, body mass index; H/Q, hamstrings/quadriceps; PT, peak torque.

Table 1 Values for each score and the final score obtained for each lower limb and the probability of injury

Corresponding points					
Risk (<55%, >64%)	No	0	Dominance of the lower limb	Non-dominant	5
	Yes	7		Dominant	0
Difference in peak torque of the knee extensor >10%	No	0	Professional history	Professional acting previous season	29
	Yes	100		Under/Youth categories in previous season	0
Difference in peak torque of the knee flexor >10%	No	0	Previous injuries—moderate to severe injuries in the last 2 years	No	0
	Yes	93		Yes	13
Body mass index	Normal	10	Current team (type of championship to be played)	First division	23
	Overweight	0		Second division	0
Age group			Playing position	Goalkeeper	
A: 18–23 years	A	0		Defender	43
B: 23–30 years	B	4		Full-back	23
C: 31–36 years	C	15		Midfielder	0
				Centre-forward	11
Mean distance of the lower limb in the single-hop test	1.4 m	51	Mean distance of the lower limb in the cross-over hop test	2.0 m	28
	1.5 m	44		2.5 m	25
	1.6 m	38		3.0 m	23
	1.7 m	32		3.5 m	20
	1.8 m	25		4.0 m	17
	1.9 m	19		4.5 m	14
	2.0 m	13		5.0 m	11
	2.1 m	06		5.5 m	08
	2.2 m	0		6.0 m	06
				6.5 m	03
				7.0 m	0

	Final score	
58: 1%	190: 30%	250: 70%
116: 5%	206: 40%	269: 90%
143: 10%	220: 50%	298: 90%
171: 20%	234: 60%	324: 95%

1. *H/Q ratio:* If the H/Q ratio was <55% or >64%, the score was 7. If the H/Q ratio was between 55% and 64%, the score was 0.
2. *Difference in PT of the knee* extensor >10%: If the PT of the knee extensor was at least 10%, compared with the contralateral limb, the score was 100, or 0 when the difference was not >10%.
3. *Difference in PT of the knee flexor* >10%: If the PT of the knee flexor was at least 10%, compared with the contralateral limb, the score was 93, or 0 if the difference was not >10%.
4. *BMI:* Score was 10 if BMI was within normal range (18.50–24.99), 0 if it was considered overweight (25.00–29.99) or obese (≥30.00).
5. *Age group*: Score was 0 if the athlete was in group A (18–23 years and 11 months); 4 for group B (24–29 years and 11 months); and 15 for group C (≥30 years).
6. *Dominance of the lower limb*: Score was 5 for the non-dominant leg or 0 for the preferred leg used to kick the ball.
7. *Professional history*: Score was 29 if the athlete had played in the previous season and 0 if he was playing in a youth team.
8. *Previous injuries*: Score was 13 if the answer was yes (moderate/severe injuries) in the last two years or 0 if no injury.
9. *Current championship level*: Score was 23 if the elite team was playing in the championship or score 0 if the athlete was playing in a youth team.
10. *Playing position*: Score was 13 for goalkeeper, 43 for defender, 23 for full-back, 0 for midfielder and 11 points for centre-forward.
11. *For the functional hop test (SHT and COHDT)*: The hop distances were set at 10 to 10 cm (SHT) and from 50 to 50 cm (COHDT) for the score. However, if the

results achieved during the tests ranged between these values, the higher value was considered to establish the test score for these tasks (table 1).

Limitations of this study

Some of the main limitations of our study include the use/application of the nomogram only in players who participated of the largest Brazilian State Championship. According to the hierarchy established in previous studies on the use of clinical prediction models,[48] this nomogram was evaluated and reported with up to level 3 *evidence* (on a scale of 1–4). It may be used clinically with criteria since the demographic data and professional profile of the study population were similar in relation to the nomograms validated internally and prospectively in a small sample. However, the level of evidence can reach up to 2 or 1 in further studies that will evaluate its validation using other samples or larger samples. Another limitation is that all the athletes were from Brazil. This aspect could have significant effects on the scores of athletes from other countries. However, several Brazilian football players are participating in several leagues around the world without significant differences in their injury rates compared with other athletes. Moreover, many athletes who participated in the original study have already played in European championships, which can avoid extrapolation bias of results.

CONCLUSIONS

To our knowledge, this was the first nomogram in literature constructed to estimate the individual risk for injury during the football championship season. Risk factor data were collected from all of the professional players during the preseason. This is the kick-off for the use of a promising, practical and easy-to-use tool for the complex logistics of training sessions and evaluations in the preseason of professional football. Further studies that may replicate this study design using other samples or larger samples are necessary to obtain an external validation and expand its use to different populations.

Acknowledgements The authors thank the University of São Paulo (USP). They further acknowledge the cooperation of the participants in the study.

Funding The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

Competing interests None declared.

Patient consent Obtained.

Ethics approval This study and the informed consent form related to this same study was approved by the Ethics Committee of the University.

Provenance and peer review Not commissioned; externally peer reviewed.

Data sharing statement All study data may be shared with the journal's editorial staff if necessary.

REFERENCES

1. Koch M, Zellner J, Berner A, *et al*. Influence of preparation and football skill level on injury incidence during an amateur football tournament. *Arch Orthop Trauma Surg* 2016;136:353–60.
2. Arnason A, Sigurdsson SB, Gudmundsson A, *et al*. Risk factors for injuries in football. *Am J Sports Med* 2004;32(suppl):5–16.
3. Devan MR, Pescatello LS, Faghri P, *et al*. A prospective study of overuse knee injuries among female athletes with muscle imbalances and structural abnormalities. *J Athl Train* 2004;39:263–7.
4. Söderman K, Alfredson H, Pietilä T, *et al*. Risk factors for leg injuries in female soccer players: a prospective investigation during one out-door season. *Knee Surg Sports Traumatol Arthrosc* 2001;9:313–21.
5. Witvrouw E, Danneels L, Asselman P, *et al*. Muscle flexibility as a risk factor for developing muscle injuries in male professional soccer players. A prospective study. *Am J Sports Med* 2003;31:41–6.
6. Bradley PS, Portas MD. The relationship between preseason range of motion and muscle strain injury in elite soccer players. *J Strength Cond Res* 2007;21:1155–9.
7. Ibrahim A, Murrell GA, Knapman P. Adductor strain and hip range of movement in male professional soccer players. *J Orthop Surg* 2007;15:46–9.
8. Mandelbaum BR, Silvers HJ, Watanabe DS, *et al*. Effectiveness of a neuromuscular and proprioceptive training program in preventing anterior cruciate ligament injuries in female athletes: 2-year follow-up. *Am J Sports Med* 2005;33:1003–10.
9. Caraffa A, Cerulli G, Projetti M, *et al*. Prevention of anterior cruciate ligament injuries in soccer. A prospective controlled study of proprioceptive training. *Knee Surg Sports Traumatol Arthrosc* 1996;4:19–21.
10. Ekstrand J, Gillquist J. Soccer injuries and their mechanisms: a prospective study. *Med Sci Sports Exerc* 1983;15:267–70.
11. Devan MR, Pescatello LS, Faghri P, *et al*. A prospective study of overuse knee injuries among female athletes with muscle imbalances and structural abnormalities. *J Athl Train* 2004;39:263–7.
12. Ostenberg A, Roos H. Injury risk factors in female European football. A prospective study of 123 players during one season. *Scand J Med Sci Sports* 2000;10:279–85.
13. Nielsen AB, Yde J. Epidemiology and traumatology of injuries in soccer. *Am J Sports Med* 1989;17:803–7.
14. Gabbe BJ, Bennell KL, Finch CF, *et al*. Predictors of hamstring injury at the elite level of Australian football. *Scand J Med Sci Sports* 2006;16:7–13.
15. Orchard JW. Intrinsic and extrinsic risk factors for muscle strains in Australian football. *Am J Sports Med* 2001;29:300–3.
16. Verrall GM, Slavotinek JP, Barnes PG, *et al*. Clinical risk factors for hamstring muscle strain injury: a prospective study with correlation of injury by magnetic resonance imaging. *Br J Sports Med* 2001;35:435–9.
17. Ekstrand J, Tropp H. The incidence of ankle sprains in soccer. *Foot Ankle* 1990;11:41–4.
18. Inklaar H, Bol E, Schmikli SL, *et al*. Injuries in male soccer players: team risk analysis. *Int J Sports Med* 1996;17:229–34.
19. Lewin G. The incidence of injury in an English professional soccer club during one competitive season. *Physiotherapy* 1989;75:601–5.
20. Lüthje P, Nurmi I, Kataja M, *et al*. Epidemiology and traumatology of injuries in elite soccer: a prospective study in Finland. *Scand J Med Sci Sports* 1996;6:180–5.
21. Hawkins RD, Hulse MA, Wilkinson C, *et al*. The association football medical research programme: an audit of injuries in professional football. *Br J Sports Med* 2001;35:43–7.
22. Junge A, Dvorak J, Graf-Baumann T. Football injuries during the World Cup 2002. *Am J Sports Med* 2004;32(Supplsuppl):23–7.
23. Waldén M, Hägglund M, Ekstrand J. UEFA champions league study: a prospective study of injuries in professional football during the 2001-2002 season. *Br J Sports Med* 2005;39:542–6.
24. Woods C, Hawkins RD, Maltby S, *et al*. . The Football Association Medical Research Programme: an audit of injuries in professional football–analysis of hamstring injuries. *Br J Sports Med* 2004;38:36–41.
25. Woods C, Hawkins R, Hulse M, *et al*. The football association medical research programme: an audit of injuries in professional football-analysis of preseason injuries. *Br J Sports Med* 2002;36:436–41.
26. Silva AA, Bittencourt NF, Mendonça LM, *et al*. Analysis of the profile, areas of action and abilities of Brazilian sports physical

therapists working with soccer and volleyball. *Rev Bras Fisioter* 2011;15:219–26.
27. Bahr R. Why screening tests to predict injury do not work-and probably never will…: a critical review. *Br J Sports Med* 2016;50:776–80.
28. van Dyk N, Bahr R, Whiteley R, *et al*. Hamstring and quadriceps isokinetic strength deficits are weak risk factors for hamstring strain injuries: a 4-year cohort study. *Am J Sports Med* 2016;44:1789–95.
29. van Dyk N, Bahr R, Burnett AF, *et al*. A comprehensive strength testing protocol offers no clinical value in predicting risk of hamstring injury: a prospective cohort study of 413 professional football players. *Br J Sports Med* 2017;51:1695–702.
30. Frohm A, Heijne A, Kowalski J, *et al*. A nine-test screening battery for athletes: a reliability study. *Scand J Med Sci Sports* 2012;22:306–15.
31. Flodström F, Heijne A, Batt ME, *et al*. The nine test screening battery - normative values on a group of recreational athletes. *Int J Sports Phys Ther* 2016;11:936–44.
32. Bakken A, Targett S, Bere T, *et al*. 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. *Br J Sports Med* 2017:bjsports-2016-097307.
33. Hägglund M, Waldén M, Ekstrand J. Exposure and injury risk in Swedish elite football: a comparison between seasons 1982 and 2001. *Scand J Med Sci Sports* 2003;13:364–70.
34. Logerstedt D, Grindem H, Lynch A, *et al*. Single-legged hop tests as predictors of self-reported knee function after anterior cruciate ligament reconstruction: the Delaware-Oslo ACL cohort study. *Am J Sports Med* 2012;40:2348–56.
35. Noyes FR, Barber SD, Mangine RE. Abnormal lower limb symmetry determined by function hop tests after anterior cruciate ligament rupture. *Am J Sports Med* 1991;19:513–8.
36. Almosnino S, Dvir Z, Bardana DD. Consistency of strength curves for determining maximal effort production during isokinetic knee testing of anterior cruciate ligament-deficient patients. *Physiother Theory Pract* 2016;32:202–8.
37. Jensen MP, Karoly P, Braver S. The measurement of clinical pain intensity: a comparison of six methods. *Pain* 1986;27:117–26.
38. Arnason A, Sigurdsson SB, Gudmundsson A, *et al*. Risk factors for injuries in football. *Am J Sports Med* 2004;32(suppl):5–16.
39. Gastin PB, Meyer D, Huntsman E, *et al*. Increase in injury risk with low body mass and aerobic-running fitness in elite Australian football. *Int J Sports Physiol Perform* 2015;10:458–63.
40. Magalhães J, Oliveira J, Ascensão A, *et al*. Concentric quadriceps and hamstrings isokinetic strength in volleyball and soccer players. *J Sports Med Phys Fitness* 2004;44:119–25.
41. Ruas CV, Minozzo F, Pinto MD, *et al*. Lower-extremity strength ratios of professional soccer players according to field position. *J Strength Cond Res* 2015;29:1220–6.
42. Reis GF, Santos TR, Lasmar RC, *et al*. Sports injuries profile of a first division Brazilian soccer team: a descriptive cohort study. *Braz J Phys Ther* 2015;19:390–7.
43. Davidian M, Giltinan DM. *Nonlinear models for repeated measurement data*. New York: Chapman and Hall.
44. Kattan MW. Nomograms. Introduction. *Semin Urol Oncol* 2002;20:79–81.
45. Blanch P, Gabbett TJ. Has the athlete trained enough to return to play safely? The acute:chronic workload ratio permits clinicians to quantify a player's risk of subsequent injury. *Br J Sports Med* 2016;50:471–5.
46. Croisier JL, Ganteaume S, Binet J, *et al*. Strength imbalances and prevention of hamstring injury in professional soccer players: a prospective study. *Am J Sports Med* 2008;36:1469–75.
47. O'Brien J, Donaldson A, Finch CF. It will take more than an existing exercise programme to prevent injury. *Br J Sports Med* 2016;50:1–2.
48. McGinn TG, Guyatt GH, Wyer PC, *et al*. Users' guides to the medical literature: XXII: how to use articles about clinical decision rules. Evidence-Based Medicine Working Group. *JAMA* 2000;284:79–84.