ORIGINAL ARTICLE

Nr 2024;14 (2):307-312

The Screening Value of Single Leg Squat and Vertical Drop Jump for Predicting Lower Limb Injuries in Professional Male Football Players

Haniyeh Mohammadi[1], Raheleh Ghaffari[2], Mahdi Hosseinzadeh[3]

[1] *Sport Injuries and Corrective Exercises, Faculty of Physical Education and Sports Sciences, Shomal University, Amol, Iran*
[2] *Sport Injuries & Corrective Exercises, Faculty of Sport Science, Shomal University, Amol, Iran*
[3] *Department of Sport Injuries and Corrective Exercises, Sport Sciences Research Institute, Tehran, Iran*

CORRESPONDING AUTHOR:
Mahdi Hosseinzadeh
Department of Sport Injuries and Corrective Exercises
Sport Sciences Research Institute
5th Alley No. 3, Miremad Street, Motahhari Street
Tehran, Iran
E-mail: Metti@ssrc.ac.ir

DOI:
10.32098/mltj.02.2024.10

LEVEL OF EVIDENCE: 2

SUMMARY

Objective. To evaluate the ability of Single Leg Squat (SLS) and Vertical Drop Jump (VDJ) tests to predict lower limb injuries in professional footballers.

Methods. In a prospective cohort study SLS and VDJ scores were recorded before the start of the season and the lower limb injuries were recorded as followed up during a 9-month season (2021-2022). Logistic regression analysis was used to determine the accuracy of the prognosis of SLS and VDJ tests.

Results. During the nine months of follow up, a total of twenty-five lower limb injuries (in twenty-three footballers) were recorded for 121 professional male footballers. The model explained 22% (Nagelkerke R2) of the variance in lower limb injury and correctly predicted 85.1% of cases. ROC analysis showed significant accuracy of the VDJ performance score of the footballer (AUC 0.659, 95%CI 3.639-63.434, p = 0.001, OR = 0.204) in discriminating between injured and uninjured players. The optimum cut-off level of the VDJ performance score of the football players was 0.5.

Conclusions. VDJ test is a suitable tool for predicting lower limb injuries in professional male footballers, but SLS cannot be used as a reliable screening tool.

KEY WORDS

Single leg squat test; vertical drop jump test; screening test; football player; sports medicine; soccer.

INTRODUCTION

Complications caused by football injuries, including damage to the player's individual health and the economic, social and health system (1), have led researchers to injury prevention programs and identification of risk factors (2, 3). In elite football, 30.3 to 47.9% of injuries that lead to loss of time for training and competition are related to the lower limbs (4). Since biomechanical and neuromuscular factors are internal variables that can be developed, these injuries can be reduced as much as possible by following an organized prevention program. Neuromuscular defects cause disturbances in balance, strength, power and create patterns that increase joint loads and compensatory movements in the lower limbs (5, 6). One of the critical movements that cause ACL injury in players is the landing phase after jumping (heading in football) (7). Knee loading and knee motion during landing predicts the risk of anterior cruciate ligament injury in female athletes (8). Among the injury prevention programs are functional movement screening tests that are challenging *per se* (9-11). These functional tests are suitable tools for evaluating the functional capacity of the lower limb and analyzing injury risk factors (12). The Single Leg Squat (SLS) and Vertical Drop Jump (VDJ) tests are among the functional tests that are used to identify core strength and biomechanics after landing (13, 14). To date, conflicting evidence has been found regarding the effectiveness of these tests in predicting injury risk. Petushek *et al.* used SLS and VDJ tests in order

to screen athletes prone to anterior cruciate ligament injury. According to their findings, there was no relationship between these two tests and the risk of future injury in athletes (15). In another study, the SLS test, however, was introduced as a suitable tool for use in sports examinations to evaluate dynamic knee valgus and the risk of lower limb injury (16). Redler *et al*. also demonstrated the validity of a field-based observational vertical drop jump test as a screening tool to identify athletes at risk for ACL injury (17). To the best knowledge of the authors the findings regarding the screening value of SLS and VDJ is not clear enough and contradictory findings has been reported. Furthermore, such research has not been conducted on a professional population of Iranian football players. The purpose of the present study was therefore to investigate the screening value of SLS and VDJ scores for predicting lower limb injuries in professional Iranian male football players.

MATERIALS AND METHODS

Participants

The participants included 121 professional male football players of the National League One (Azadegan League) – age: 22.78 ± 4.60 years, height: 180.02 ± 5.09 cm, weight: 72.45 ± 6.26 Kg, BMI: 22.29 ± 1.34 Kg/m^2) – who were expected to participate in the 2021-2022 season. Registration of player injuries was prospectively followed for one football season (about 9 months).

Procedures

This study was conducted based on the principles of the Declaration of Helsinki and its latest amendments, and the study protocol was approved by the research ethics committee of Sport Science Research Institute of Iran (IR.SSRC.REC.1401.084 – date of approval: December 21, 2022). All players signed an informed consent form to participate in the study. Participants had the right to withdraw from the study at any stage without further notice.

In a briefing session, the football players were taught the correct procedures and procedures for performing SLS and VDJ tests. A physical therapist with three years' sport experience checked the health of the participants before entering the test. All the functional tests were conducted on the football field in order to standardize the application of tests, and to simulate football matches.

Functional screening tests

Before performing the tests, the athletes performed a standard warm-up procedure including (5 minutes of running, dynamic stretching, small skips, open and close the gate, heel kicks, low shuffle and carioca) (18). An experienced athletic trainer (more than 3 years of physical therapy practice, expert in evaluating individuals' sport performance through SLS and VDJ in their daily clinical practice) participated as the evaluator.

Single leg squat

This test was performed similar to the single leg squat test described by Sciascia and Kibler (19). The athletes were asked to put their hands on their waists and bend 90 degrees on one leg while looking forward. If the athletes keep the opposite leg in front of the body during the squat, the opposite leg touches the standing leg, the opposite leg touches the ground, the hands are removed from both sides of the body, or if the athlete loses his balance, the test was considered invalid. The performance of the right and left leg was recorded separately. All the participants started the test with the right foot (20). Athletes' ability to control their knee in the frontal plane was evaluated using a graded scoring scale from 0 to 2. A score of zero equaled good control. In fact, the participant demonstrates proper alignment with a straight line from the knee to the toes, no obvious valgus movement in either knee, and no mediolateral knee sway during performance. A score of one corresponded to decreased control and indicated poor alignment, with one or both knees moving into a mild valgus position and some knee sway during performance. Score 2 corresponded to poor control and this score was considered when the knee alignment was weak and at least one knee was clearly and significantly in valgus or there was significant mediolateral sway during performance. The scoring criteria for the hip was the same as for the knee, but the focus was on hip motion/tilt. Specifically, scores of 0, 1, and 2 was given for no, some, and significant pelvic lateral tilt, respectively. After separate scores, the hip and knee asymmetry score was calculated with the absolute difference between the two sides, where 0 indicates symmetry, 1 is moderate asymmetry, and 2 is high asymmetry (15). Ordinal scale measures displayed intrarater reliability ranging from 0.38 to 0.94 and interrater reliability of 0.68 (0.46-0.87). Intrarater reliability of frontal plane knee measures ranged from 0.88 to 0.98 and interrater reliability of 0.99 (0.97-1.00) (21).

Vertical drop jump

To evaluate knee control in the frontal plane, athletes performed the VDJ test from a 20 cm box. Starting the exercise from the top of the box, the athletes were instructed to land from the box using a symmetrical landing strategy and immediately after to perform a maximal vertical jump.

To normalize the test with soccer conditions and to ensure that the athletes perform the jump with maximum effort and concentration, a soccer ball was thrown by the evaluator towards the footballers, and the footballers blocked the ball by heading and immediately landed on the ground. If the athletes did not perform the landing strategy correctly or did not perform the vertical jump with maximum effort after the first landing, the test was considered invalid. The athletes were allowed to do 2 practice trials before the test, then they did the valid and main test. Athletes' ability to control their knees in the frontal plane during the jump landing phase was evaluated using a scoring scale from 0 to 2. A total score for both legs was used for scoring. The scoring criteria for the knee were the same as the SLS criteria (15). Intrarater reliability for VDJ was reported as substantial to almost perfect (kappa 0.72 rater 1; 0.85 rater 2). Interrater reliability was reported as substantial to almost perfect (kappa from 0.68 to 0.83) (22).

Injury record

The lower limb injury status of each athlete was recorded until the end of the competition season through monthly contact or sending an online form to the player. At the end of each month, if a player had not completed his injury form, the evaluator, H.M., contacted the sports coach or the team doctor to follow up on the completion of the injury registration form. All lower limb injuries (contact and non-contact) that kept the individual out of training or competition for 24 hours, causing a visit to the doctor were recorded and considered an injury (23).

Statistical analysis

Data analysis was analyzed in two parts, descriptive and inferential statistics using SPSS for Windows, version 26.0, (SPSS Inc., Chicago, pernios, USA software). The normality of the data was evaluated using the Kolmogorov-Smirnov statistical test. The comparison of two groups of footballers (injured footballers and non-injured footballers) was investigated with Student's t test. The predictive value of SLS and VDJ was investigated using logistic regression. A ROC curve was conducted to determine a cutoff point for VDJ whereby injury risk was identified to increase. The statistical significance level was 0.05 and effect sizes with 95%CI are presented for all outcomes. Where appropriate, effect sizes were quantified using odds ratios (OR) and considered trivial (0.77-1.00 or 1.00-1.29), small (0.51-0.78 or 1.30-1.99), moderate (0.25-0.50 or 2.00-3.99), and large (≤ 0.24 or ≥ 4.00) (24).

RESULTS

Twenty-five lower limb sport injuries were recorded for 121 male footballers during the 9-month follow-ups. Age, height, weight, BMI, and score of the screening tests of all the players, and also injured and uninjured players are showed in **table I**. Comparisons of the score of the screening tests were statistically different between the injured *vs* uninjured footballers (all $p \leq 0.05$) (**table I**).

The separate model created by the logistic regression analysis for score of the screening tests is provided in **table II**. This model for SLS was not statistically significant ($\chi^2(1) = 0.967$, $p > 0.05$). However, this model for VDJ was statistically significant ($\chi^2(1) = 17.794$, $p < 0.001$). The model explained 22% (Nagelkerke R2) of the variance in lower limb injury and correctly predicted 85.1% of cases. Finally, ROC analysis (**figure 1**) showed significant accuracy of the curve for the VDJ performance score of the footballers (AUC 0.659, AUC 95%CI 3.639-63.434, $p = 0.001$) in discriminating between injured and uninjured players. The optimum cut-off level of the VDJ performance score of the footballers was 0.50 (where sensitivity was 0.969, and specificity was 0.652). The frequency of the injuries per location is provided in **table III**.

Table I. Characterization of the total sample study population and the results of the statistical comparisons between footballers with or without MSI.

	Participants enrolled total (n = 121) Mean ± SD	Uninjured players (n = 98) Mean ± SD	Injured players (n = 23) Mean ± SD	P-value	Effect size d (95%CI)
Age (years)	22.78 ± 4.60	23.03 ± 4.65	21.70 ± 4.27	0.29	-
Height, cm	180.02 ± 5.09	180.32 ± 4.82	178.78 ± 6.10	0.22	-
Weight, Kg	72.45 ± 6.26	72.38 ± 6.17	72.74 ± 6.77	0.50	-
Body Mass Index (BMI)	22.29 ± 1.34	22.23 ± 1.32	22.59 ± 1.41	0.492	-
SLS (n)	0.37 ± .565	0.35 ± 0.558	0.48 ± 0.593	0.341	-
VDJ (n)	0.10 ± .327	0.03 ± 0.173	0.39 ± 0.583	0.001	1.22 (0.76-1.68)

SLS: single leg squat; VDJ: vertical drop jump; n: number.

Table II. Significance of risk factors for MSI in the logistic regression creating a separate model with VDJ and SLS.

	Coefficient	P-value	R2 (Nagelkerke)	Exp(B)	95%CI
SLS (n)	0.387	0.317	0.01	1.473	0.690-3.144
VDJ (n)	2.721	0.001	0.22	15.193	3.639-63.434

SLS: single leg squat; VDJ: vertical drop jump; n: number.

Table III. Injury locations.

Injury locations	Frequency
Ligament and knee injuries	32%
Muscle injuries	36%
Leg injuries	4%
Ankle sprain	28%
Total	100%

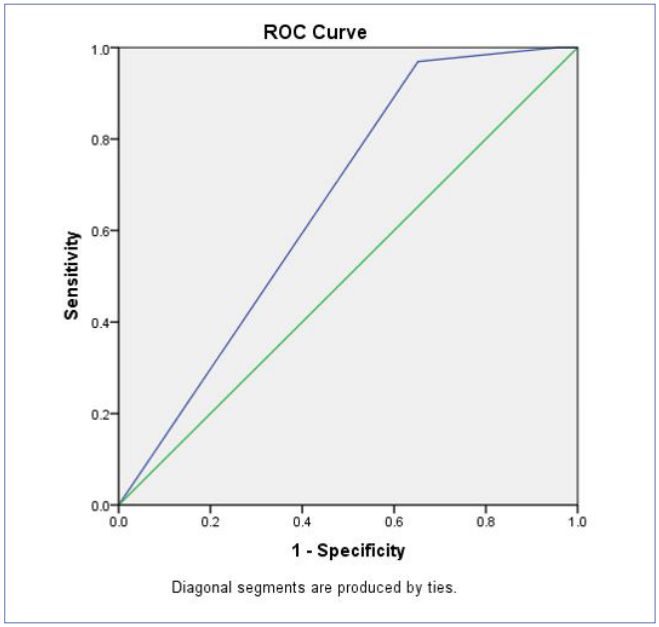

Figure 1. Receiver operating characteristic (ROC) curve for the VDJ score of the footballers participating in this study.

The straight line shows the reference line, which was approximated by the ROC curve plotted on sensitivity (true positive rate) over 1-specificity (false positive rate) for the VDJ.

DISCUSSION

The present study investigated the ability of SLS and VDJ tests in predicting lower limb injuries in Iranian professional male football players. Our findings showed that the VDJ test can be used as a suitable tool for pre-season screening of professional football players. Field evaluations of biomechanics are associated with injury risk in football players (25). Considering that a suitable screening tool should have high sensitivity, it was shown that the sensitivity of VDJ = 96%, which means that most football players are screened by this test. Knee valgus is considered an important part of football injuries (26) so the scoring method in these tests was based on knee biomechanics. Since good inter- and intra-rater reliability and high sensitivity of VDJ test has been shown (27), this test was used in this research to identify football players prone to injury. Previous research has shown that increased valgus motion and valgus moments at the knee joint during landing jump tasks are key predictors of ACL injury in athletes (8). Contrary to the study of Tron Krosshaug and colleagues, who found in a prospective study on 710 elite female athletes that the VDJ test is not able to predict ACL injury in elite female athletes (28), considering that one of the situations that cause ACL injury in footballs heading (26), in the current study, the VDJ test was simulated with this situation, and when performing the test with the player's jump, the examiner threw a ball at his head and the player had to perform the act of heading. Tests commonly used to assess dynamic knee valgus, such as squats or jump-landing tasks, may show different results. Although the same movement pattern is used in both tests, which includes bending and extension of the trunk, knees, wrists, and hips in the sagittal plane, the landing task bears more external load than the squat (29). The present study showed that SLS is not able to predict lower limb injuries in professional male football players, which is contrary to the findings of Ugalde *et al.*, who introduced this test as a suitable screening tool (16). One of the reasons for this inconsistency can be the examiner's inaccuracy in the visual evaluation, and we also declared the squat depth to be 90 degrees, which caused variation in the amount of effort and sitting of the players.

Study limitations

In the previous studies, video analysis was used to check the visual tests, but in the present study, due to cost and time saving, these functional tests were performed visually. One of the limitations of the study is the lack of examination of previous injuries and exposure time, which the players and coaches did not provide to us due to personal reasons. Also, in this study, we did not compare side-by-side differences and used a general score for both sides. Future studies should also be conducted for women soccer players.

CONCLUSIONS

Identifying athletes prone to injury is an important step towards the health of athletes and increasing the quality of sports. The results of the present study showed that, unlike the SLS test, which did not have the ability to predict lower limb injuries in professional male soccer players, the VDJ test is a suitable tool for assessing injury-prone football players. Sports team coaches and team medical staff can use VDJ as a screening tool to predict lower limb injuries in professional football players and to identify people prone to injury during the pre-season and before signing contracts with players. In this way, this screening tool reduces the medical and health costs incurred by the player and the team during the injury.

FUNDINGS

None.

DATA AVAILABILITY

Data are available under reasonable request to the corresponding author.

CONTRIBUTIONS

HM, MH: writing – original draft, formal analysis. HM: data curation, investigation. MH: writing – review & editing. RG: writing – review & editing

CONFLICT OF INTERESTS

The authors declare that they have no conflict of interests.

REFERENCES

1. Owoeye OBA, VanderWey MJ, Pike I. Reducing Injuries in Soccer (Football): an Umbrella Review of Best Evidence Across the Epidemiological Framework for Prevention. Sports Med Open. 2020;6(1):46. doi: 10.1186/s40798-020-00274-7.
2. Bencke J, Strøm M, Curtis DJ, Bandholm T, Zebis MK. Differences in Thigh Muscle Activation Between Standing and Landing Exercises for Knee Injury Prevention and Rehabilitation. Int J Sports Phys Ther. 2023;18(1):102-12. doi: 10.26603/001c.67829.
3. Volpi P, Taioli E. The health profile of professional soccer players: future opportunities for injury prevention. J Strength Cond Res. 2012;26(12):3473-9. doi: 10.1519/JSC.0b013e31824e195f.
4. Hughes T, Riley RD, Callaghan MJ, Sergeant JC. The Value of Preseason Screening for Injury Prediction: The Development and Internal Validation of a Multivariable Prognostic Model to Predict Indirect Muscle Injury Risk in Elite Football (Soccer) Players. Sports Med Open. 2020;6(1):22. doi: 10.1186/s40798-020-00249-8.
5. Saki F, Daneshmandi H, Rajabi R, Mohammadpour S. Neuromuscular and biomechanical risk factors associated with ACL injury in female athletes. Scientific J Kurdistan Uni Me Sci. 2013;18(3):112-23.
6. Olsen O-E, Myklebust G, Engebretsen L, Holme I, Bahr R. Exercises to prevent lower limb injuries in youth sports: cluster randomised controlled trial. BMJ. 2005;330(7489):449. doi: 10.1136/bmj.38330.632801.8F.
7. Molinaro L, Taborri J, Santospagnuolo A, Vetrano M, Vulpiani MC, Rossi S. Sensor-based indices for the prediction and monitoring of anterior cruciate ligament injury: reliability analysis and a case study in basketball. Sensors. 2021;21(16):5341. doi: 10.3390/s21165341.
8. Hewett TE, Myer GD, Ford KR, et al. Biomechanical measures of neuromuscular control and valgus loading of the knee predict anterior cruciate ligament injury risk in female athletes: a prospective study. Am J Sports Med. 2005;33(4):492-501. doi: 10.1177/0363546504269591.
9. Dallinga JM, Benjaminse A, Lemmink KA. Which screening tools can predict injury to the lower extremities in team sports?: a systematic review. Sports Med. 2012;42(9):791-815. doi: 10.1007/BF03262295.
10. Zarei M, Soltanirad S, Kazemi A, Hoogenboom BJ, Hosseinzadeh M. Composite functional movement screen score predicts injuries in youth volleyball players: a prospective cohort study. Scientific Reports. 2022;12(1):20207. doi: 10.1038/s41598-022-24508-8.
11. Mian Darbandi S, Hosseinzadeh M, Zarei M, Behm DG. Does ipsilateral and bilateral knee strength status predict lower extremity injuries of elite judokas; a prospective cohort study. Res Sports Med. 2024;32(3):465-78. doi: 10.1080/15438627.2022.2126777.
12. Manoel LS, Xixirry MG, Soeira TP, Saad MC, Riberto M. Identification of ankle injury risk factors in professional soccer players through a preseason functional assessment.

Orthop J Sports Med. 2020;8(6):2325967120928434. doi: 10.1177/2325967120928434.
13. Okada T, Huxel KC, Nesser TW. Relationship between core stability, functional movement, and performance. J Strength Cond Res. 2011;25(1):252-61. doi: 10.1519/JSC.0b013e3181b22b3e.
14. Stensrud S, Myklebust G, Kristianslund E, Bahr R, Krosshaug T. Correlation between two-dimensional video analysis and subjective assessment in evaluating knee control among elite female team handball players. Br J Sports Med. 2011;45(7):589-95. doi: 10.1136/bjsm.2010.078287.
15. Petushek E, Nilstad A, Bahr R, Krosshaug T. Drop jump? Single-leg squat? Not if you Aim to predict anterior cruciate ligament injury from real-time clinical assessment: A prospective cohort study involving 880 elite female athletes. J Orthop Sports Phys Ther. 2021;51(7):372-8. doi: 10.2519/jospt.2021.10170.
16. Ugalde V, Brockman C, Bailowitz Z, Pollard CD. Single leg squat test and its relationship to dynamic knee valgus and injury risk screening. PM R. 2015;7(3):229-35; quiz 235. doi: 10.1016/j.pmrj.2014.08.361.
17. Redler LH, Watling JP, Dennis ER, Swart E, Ahmad CS. Reliability of a field-based drop vertical jump screening test for ACL injury risk assessment. Phys Sportsmed. 2016;44(1):46-52. doi: 10.1080/00913847.2016.1131107.
18. Redd MJ, Starling-Smith TM, Herring CH, Stock MS, Wells AJ, Stout JR, et al. Tensiomyographic Responses to Warm-Up Protocols in Collegiate Male Soccer Athletes. J Funct Morphol Kinesiol. 2021;6(4):80. doi: 10.3390/jfmk6040080.
19. Sciascia A, Kibler WB. Alterations in the kinetic chain are found in a high percentage of injured patients--Conducting the" nonshoulder" shoulder examination. J Musculoskele Med. 2006;23(8):582.
20. Liebenson C. Functional training for performance enhancement—Part 1: the basics. J Bodywork Movement Ther. 2006;10(2):154-8.
21. Poulsen DR, James CR. Concurrent validity and reliability of clinical evaluation of the single leg squat. Physiother Theory Pract. 2011;27(8):586-94. doi: 10.3109/09593985.2011.552539.
22. Lindblom H, Hägglund M, Sonesson S. Intra- and interrater reliability of subjective assessment of the drop vertical jump and tuck jump in youth athletes. Phys Ther Sport. 2021;47:156-64. doi: 10.1016/j.ptsp.2020.11.031.
23. O'Connor FG, Deuster PA, Davis J, Pappas CG, Knapik JJ. Functional movement screening: predicting injuries in officer candidates. Med Sci Sports Exerc. 2011;43(12):2224-30. doi: 10.1249/MSS.0b013e318223522d.
24. Hopkins WG. Statistics used in observational studies. Sports Injury Res. 2010;16(1):69.
25. Collings TJ, Diamond LE, Barrett RS, et al. Strength and Biomechanical Risk Factors for Non-contact ACL Injury in Elite Female Footballers: A Prospective Study. Med Sci Sports Exerc. 2022;54(8):1242-51. doi: 10.1249/MSS.0000000000002908.
26. Waldén M, Krosshaug T, Bjørneboe J, Andersen TE, Faul O, Hägglund M. Three distinct mechanisms predominate in non-contact anterior cruciate ligament injuries in male professional football players: a systematic video analysis of 39 cases. Br J Sports Med. 2015;49(22):1452-60. doi: 10.1136/bjsports-2014-094573.
27. Redler LH, Watling JP, Dennis ER, Swart E, Ahmad CS. Reliability of a field-based drop vertical jump screening test for ACL injury risk assessment. Phys Sportsmed. 2016;44(1):46-52. doi: 10.1080/00913847.2016.1131107.
28. Krosshaug T, Steffen K, Kristianslund E, Nilstad A, Mok K-M, Myklebust G, et al. The vertical drop jump is a poor screening test for ACL injuries in female elite soccer and handball players: a prospective cohort study of 710 athletes. Am J Sports Med. 2016;44(4):874-83. doi: 10.1177/0363546515625048.
29. Wilczyński B, Zorena K, Ślęzak D. Dynamic knee valgus in single-leg movement tasks. Potentially modifiable factors and exercise training options. A literature review. Int J Environ Res Public Health. 2020;17(21):8208. doi: 10.3390/ijerph17218208.