2019, Volume 2 (Issue 2): 7 OPEN ACCESS

Collegiate Female Athletes and Their Odds of Injury Based on Functional Movement Screen Composite Scores

Short Review

Madeline Lyons[1], Roger O. Kollock[1], Davis Hale[1]

[1]*Department of Kinesiology and Rehabilitative Sciences, University of Tulsa, Tulsa, OK, USA*

Abstract

Introduction: Female collegiate athletes experience high rates of musculoskeletal injuries. One popular strategy for the reduction of musculoskeletal injury in collegiate athletes is the use of screening tools such as the Functional Movement Screen (FMS) to identify at risk athletes. The purpose of this meta-analysis was to determine if female collegiate athletes scoring ≤ 14 are at greater odds of injury than female collegiate athletes scoring >14.

Methods: We searched MEDLINE, EBSCOhost, and PubMed databases for articles published between January 2000 and April 2019. For inclusion, all studies were required to have used the FMS to predict injury, used FMS cut-off criterion of 14, and included a sample population consisting of female collegiate athletes. In addition, they needed to have identified the total number of participants above and below the FMS cut-off criterion (or provided an odds ratio).

Results: Two studies met the inclusion criteria. The odds of female collegiate athletes sustaining injury with an FMS cutoff score of ≤14 were four times higher compared to female athletes with composite FMS scores of >14 (OR=4.12, 95% CI=1.29-13.22, p=0.017).

Conclusions: Female collegiate athletes scoring ≤14 have a four times greater odds of injury than female collegiate athletes scoring >14 on the FMS; while not the sole indicator of injury risk, clinicians should seek to address the limitations in an athlete's movement quality identified through the use of the FMS.

Key Words: Women, Sports, FMS.

Corresponding author: Roger O. Kollock, roger-kollock@utulsa.edu

Introduction

Female collegiate[1] athletes experience high rates of musculoskeletal injuries (MSI). From 2009-2014, there were an average of 80,674 injuries to female collegiate student-athletes in NCAA championship sports per year.[1] Approximately 22% of all injuries occurring in women's soccer, volleyball and basketball were severe enough to require ≥7 days before a full return to sports participation.[1] MSI can have lasting impact on an athlete's future quality of life. Former Division I athletes are shown to have a lower level of fitness compared to non-athletes later in later; this is thought to be a result of athletic limitations caused by an accumulation of athletic injuries.[2] Additionally, while 24% of non-athletes develop osteoarthritis, 40% of former Division I athletes develop osteoarthritis after college.[2]

An increasingly popular strategy for the reduction of MSI in collegiate athletes is the use of screening tools such as the Functional Movement Screen (FMS) to identify athletes at a heightened risk of injury.[3-5] The FMS consist of seven tests, each scored from on a 0-3 scale for a total maximum score of 21.[6] Higher scores indicate a better quality of movement. There is conflicting support for the use of the FMS by practitioners to identify athletes who have an elevated risk of sustaining MSI across the literature.[5,7,8] Recently several meta-analyses have been published[9-12] investigating the predictive value of the FMS as a tool for determining injury risk. In meta-analysis published in 2015, researchers found the FMS to have low sensitivity of 25% with a high specificity of 85%.[10] However, the meta-analysis used a pooled analysis that did not account for difference in cutoff scores used in each included study. In addition, researchers also did not perform separate analyses for males and females. In three more recent meta-analyses,[9,11,12] investigators did take into account cut-off scores. All of these recent meta-analyses [9,11,12] conducted analysis using a ≤14/>14 cutoff value. One [9] reported finding the odds of injury were 2.74 times greater for those scoring ≤14. This particular analysis also pooled sexes (males and females) and traditional and nontraditional athletes (e.g. military and firefighters). Pooling together traditional and nontraditional athletes may have skewed the findings. The remainder of the two meta-analyses[11,12] conducted their analyses on only tactical athletes; thus, it is difficult to extend their findings to collegiate athletes given the unique work environment of tactical athletes in which they are often require to perform job duties while wearing heavy equipment and gear.

Although there are four published meta-analyses, none provides data on the predictive value of the FMS in identifying at risk female collegiate athletes; thus, there remains a need to synthesize the available literature to determine the predictive value of the FMS in females. Best practices need to be identified for practitioners wanting to employ the FMS as tool for reducing injury risk. The purpose of this meta-analysis was to determine if female collegiate athletes scoring ≤ 14 are at greater odds of injury than female collegiate athletes scoring >14.

Methods

Data Source

The sections of this article have been written in accordance with The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA).[13] We searched MEDLINE, EBSCOhost, and PubMed databases for articles published between January 2000 and April 2019. The following terms were searched alone or in combination using the population, intervention and outcome (PIO) format using Boolean operators (OR & AND): P) athlete OR collegiate athlete AND I) FMS OR functional movement screen OR movement screen OR screening tools OR movement assessment AND O) injury OR musculoskeletal injury OR ankle injury OR knee injury OR hip injury OR shoulder injury OR back injury OR spine injury OR low back injury OR cervical spine injury OR lumbar spine injury OR thoracic spine injury OR elbow injury OR neck injury OR joint injury OR overuse injury OR traumatic injury. In addition, we searched the reference lists of the acquired articles to find additional pertinent articles. Attempts were made to contact researchers for unpublished data.

Study Selection

Inclusion criteria were determined before the start of the literature review. For inclusion, all studies were required to have used the FMS to predict injury, used FMS cut-off criterion of 14, and included a sample population consisting of female collegiate athletes. In addition, they needed to have identified the total number of participants above and below the FMS cut-off criterion (or provided an odds ratio). After screening the titles and abstracts, two reviewers (R.K., M.L.) evaluated the relevant full-text articles for final inclusion. The reviewers resolved disagreements concerning article eligibility by coming to consensus or by arbitration of a third reviewer (G.G.) if disagreement persisted.

Quality Assessment

The Scottish Intercollegiate Guidelines Network (SIGN) algorithm for classifying study design was used to classify the study design and identify the correct appraisal checklist required to appraise the quality of evidence and risk of bias inherent in each article (Table 1).[14,15] The SIGN uses the following criteria for assigning the level of evidence a particular article: 1, 2, 3, and 4.[14]

The SIGN grading system rates the risk of bias using ++ (high quality, with little or no risk of bias), + (acceptable some flaws in the study with associated risk of bias) and – (low quality with significant flaws relating to key aspects of study design). [16,17] The SIGN criteria of 1 ++ represents the highest level of evidence and would be considered a "high quality meta-analyses, systematic reviews of RCTs, or RCTs with a very low risk of bias".[14] The SIGN is a commonly used instrument used to appraise manuscripts [18,19] and determine level of selection, performance, attrition, and detection bias.[16,17] Two reviewers (R.K., M.L.) appraised each of the included articles. The reviewers resolved disagreements concerning article quality and level of bias by coming to consensus or by arbitration of a third reviewer (G.G.) if disagreement persisted.

Data Extraction
The reviewers extracted all relevant information from each eligible article: number of participants, number of total participants below and above the FMS cut-off criterion (or odds ratio), and sport (e.g. volleyball). All extracted data were entered in Comprehensive Meta-Analysis (version 3; Biostat Inc., Englewood, NJ).

Data Synthesis
A weighted random effects meta-analysis was conducted using an odds ratio, centered on 1.00 as the effects metric. The magnitude of the effects for the meta-analysis was interpreted based on the following scale: trivial (<1.5), small (≥1.5<3.5), moderate (≥3.5<9) and large (≥9).[11,20] The magnitude was determined by the lower limit of the effects.

Results
The search revealed 183 potentially relevant studies. Two studies[3,7] met the inclusion criteria (Figure 1). The characteristics of each study are described in Table 1. Due to the limited number of studies, meeting the inclusion criteria no studies were excluded from analyses based on quality of evidence. The two studies reviewed[3,7] were cohort design and provided level 2 – evidence (Table 1). The odds of female collegiate athletes sustaining injury with an FMS cutoff score of ≤14 were four times higher compared to female athletes with composite FMS scores of >14 (OR=4.12, 95% CI=1.29-13.22, p=0.017) (Figure 2).

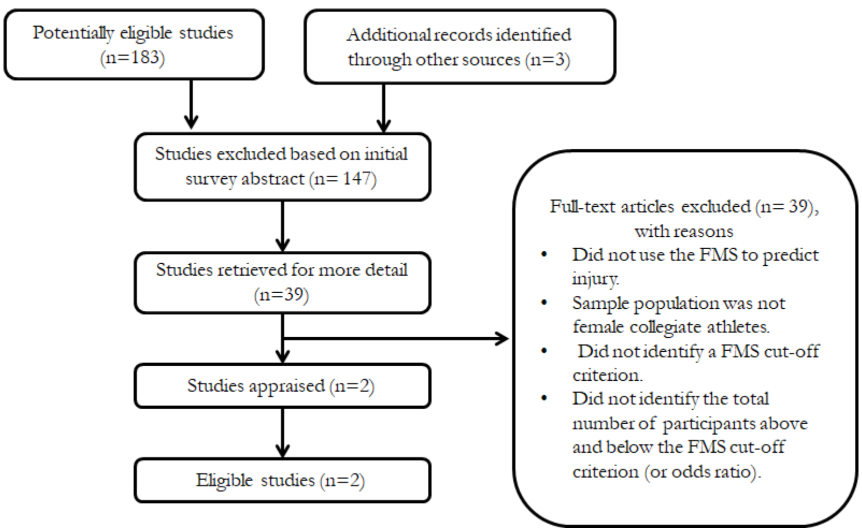

Figure 1. Outline of literature search and selection

Table 1

Study	N	Sport (level)	Age, y	Ht, cm	Mass, kg	FMS Score	Level of Evidence
Clay et al.[3]	37	Rowers (D1)	H: 19.25±1.17	H: 168.91±6.50	H: 69.49±9.14	NP	2 –
			L: 19.55±1.21	L: 172.01±8.41	L: 69.12±8.93		
Chorba et al.[7]	38	Multiple (D2)	19.24±1.20	172.29±8.51	67.45±9.58	14.3±1.77	2 –

D1, division 1; D2, division 2; H, high-risk group; L, low-risk group; Multiple, consisted of basketball, volleyball and soccer; NP, not provided

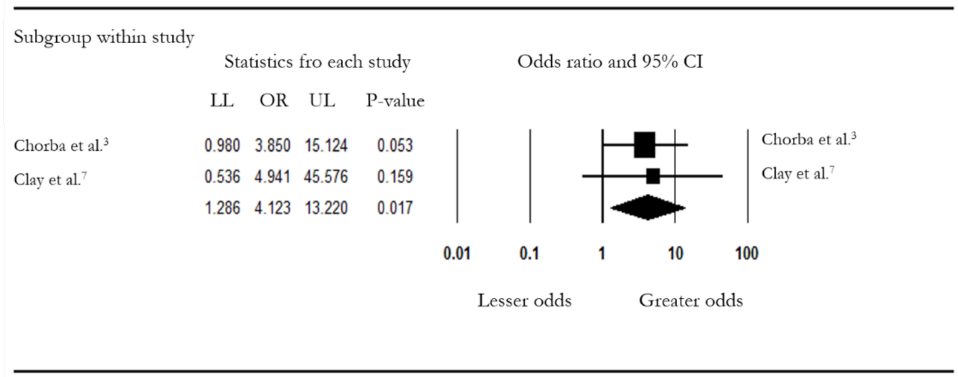

Figure 2: forest plot (Z = 2.38, P = 0.017; heterogeneity: Q = 0.04, df = 1, P = 0.851, $I^2 = 0$, $t^2 = 0$)

Discussion

The main finding of the study were that female collegiate athlete scoring ≤14 have a greater odds of injury compared to female collegiate athletes scoring >14. Specifically, we observed that the odds of injury are 4.12 times higher. This is much higher than observations in earlier meta-analyses. [9-11] Arguably, the findings are a result of filtering out males and activities other than collegiate sports. To our knowledge, this is the first study to provide data on collegiate female athletes. There has only been one published meta-analysis[12] to investigate the predictive value of the FMS in the females and that was in military personnel. The odds of injury in the current study are much higher than that observed in female military personnel. In fact, it was reported that female military personnel scoring ≤14 were not at significantly greater odds of injury compared to female personnel scoring >14.[12] The difference in findings may be due to the difference in performance environment, in which body borne loads worn by military personnel may be greater predictor of injury.

Investigators of two other meta-analyses[9,11] have reported observing that individuals scoring ≤14 were at heightened chance of injury compared to those scoring >14. Morel et al.,[11] focused on male military personnel, while Bonazza et al.[9] presented pooled results that grouped studies regardless of sport, occupation or sex. Moran et al.,[11] reported observing that male military personnel scoring ≤14 had a 1.47 greater risk of injury ($p<.001$), while Bonazza et al.,[9] observed that individuals scoring ≤14 had 2.74 greater odds of injury.

For the present analysis, two studies[3,7] met the inclusion criteria. Both studies had small sample sizes. Clay et al.,[7] had a sample of 37 division I female collegiate rowers, while Chorba et al.,[3] had a sample of 38 division II female collegiate basketball, soccer and volleyball athletes. The small sample sizes of the two studies arguably contributed the very wide effect range estimates, making conclusions less certain.[21] The present analysis revealed an odd ratio of 4.12. However, based on the lower limit (1.286) of the effects (Figure 2) the magnitude of the effects for the analysis was trivial; meaning the odds of injury could be as low as 1.286. Arguably, 1.286 odds of injury may not be clinically relevant. Thus, there may be little justification for administering the FMS to all female athletes within a collegiate athletic department given the time and personnel required to facilitate large-scale screening programs.

Based on our review, the level of evidence provided by the included studies and the analyses of the provided data, we propose a conditional recommendation for the use of the FMS with the following caveat: practitioners should not adopt the FMS as the sole indicator in classifying personnel as having a high or low risk of injury due to the poor sensitivity of the FMS as a diagnostic tool.[10,22,23] In female cadet participating in the United States Coast Guard's Summer Warfare Annual Basic training, Knapik[22] reported a sensitivity of 60.3% and a specificity of 61% when using a FMS cutoff score of ≤14/>14. In a more recent study[23] that pooled male and female collegiate athletes, it was observed that the FMS had a sensitivity of 60% and a specificity of 49% when using a cutoff score of ≤14/>14. Taken together these earlier studies highlight the inability of the FMS to correctly identify those that will go on to sustain an injury (true positive rate) or those that will not sustain an injury (true negative rate). Thus, while female collegiate athletes scoring ≤14 have a four times greater odds of injury, other confounding factors are at play. Viewing the FMS in combination with other variables such as body composition, previous injury history or level of fitness may help to provide a better indicator of injury risk. Factors such as previous injury[24] and level of fitness[25,26] have been found to be associated to injury. Because the two included studies[3,7] did not conduct analyses eliminating all individuals with a prior history of injury, we were unable to conduct a sub-analysis on females with no previous history of injury. One[3] of the included studies did provide data that excluded those with previous anterior cruciate ligament tears. The group reported an odds ratio of 4.58 in those with no history of an anterior cruciate ligament tear. More studies are required that account for previous injury history and fitness level to help to provide further insight into the relationship of FMS cut score and injury risk. Our conditional recommendation for the use, as per the SIGN guidelines, reflects the judgement that the desirable consequences likely outweigh undesirable consequences.[14] As a screening tool, the FMS can help direct practitioners to limitations in stability and mobility, and help give practitioners baseline information of an individual's ability to move.

The authors acknowledge the following limitations. First, there is a possibility that not all published or unpublished data were included in the analyses. Second, we chose to include all available data into our analyses, regardless of perceived quality, because of the limited number of studies meeting the inclusion criteria. The inclusion of only two studies arguably limits the overall impact of the study and application of our finding in helping to develop injury reduction strategies in female collegiate athletes. Future research is required to provide further insight into the FMS as a diagnostic tool in classifying injury risk in female collegiate athletes.

Media-Friendly Summary

Female collegiate athletes scoring ≤14 have four times greater odds of injury than female collegiate athletes scoring >14 on the FMS. Although it appears that athletes scoring ≤14 have a significantly greater odds of injury, findings within the literature suggest that the FMS lacks the sensitivity and specificity to be used as a diagnostic tool; thus, other confounding factors are at play. Viewing the FMS in combination with other variables such as body composition, previous injury history or level of fitness may help to provide a better indicator of injury risk.

References

1. Kerr ZY, Marshall SW, Dompier TP, Corlette J, Klossner DA, Gilchrist J. College Sports-Related Injuries - United States, 2009-10 Through 2013-14 Academic Years. *MMWR Morb Mortal Wkly Rep.* 2015;64(48):1330-1336.
2. Simon JE, Docherty CL. The Impact of Previous Athletic Experience on Current Physical Fitness in Former Collegiate Athletes and Noncollegiate Athletes. *Sports Health.* 2017;9(5):462-468.
3. Chorba RS, Chorba DJ, Bouillon LE, Overmyer CA, Landis JA. Use of a functional movement screening tool to determine injury risk in female collegiate athletes. *N Am J Sports Phys Ther.* 2010;5(2):47-54.
4. Duke SR, Martin SE, Gaul CA. Preseason Functional Movement Screen Predicts Risk of Time-Loss Injury in Experienced Male Rugby Union Athletes. *J Strength Cond Res.* 2017;31(10):2740-2747.
5. Kiesel K, Plisky PJ, Voight ML. Can Serious Injury in Professional Football be Predicted by a Preseason Functional Movement Screen? *N Am J Sports Phys Ther.* 2007;2(3):147-158.
6. Cook G. *Movement : functional movement systems : screening, assessment, and corrective strategies.* Aptos, CA: On Target Publications; 2010.
7. Clay H, Mansell J, Tierney R. Association between Rowing Injuries and the Functional Movement Screen in Female Collegiate Division I Rowers. *Int J Sports Phys Ther.* 2016;11(3):345-349.
8. Bushman TT, Grier TL, Canham-Chervak M, Anderson MK, North WJ, Jones BH. The Functional Movement Screen and Injury Risk: Association and Predictive Value in Active Men. *Am J Sports Med.* 2016;44(2):297-304.
9. Bonazza NA, Smuin D, Onks CA, Silvis ML, Dhawan A. Reliability, Validity, and Injury Predictive Value of the Functional Movement Screen: A Systematic Review and Meta-analysis. *Am J Sports Med.* 2017;45(3):725-732.

10. Dorrel BS, Long T, Shaffer S, Myer GD. Evaluation of the Functional Movement Screen as an Injury Prediction Tool Among Active Adult Populations: A Systematic Review and Meta-analysis. *Sports Health.* 2015;7(6):532-537.
11. Moran RW, Schneiders AG, Mason J, Sullivan SJ. Do Functional Movement Screen (FMS) composite scores predict subsequent injury? A systematic review with meta-analysis. *Br J Sports Med.* 2017;51(23):1661-1669.
12. Kollock RO, Lyons M, Sanders G, Hale D. The effectiveness of the functional movement screen in determining injury risk in tactical occupations. *Ind Health.* 2018.
13. Moher D LA, Tetzlaff J, Altman DG. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *J Clin Epidemiol.* 2009;62(10):1006–1012.
14. SIGN 50: A guideline developer's handbook. 2015; http://www.sign.ac.uk/assets/qrg50.pdf. Accessed October 2, 2017.
15. Harbour R, Lowe G, Twaddle S. Scottish Intercollegiate Guidelines Network: the first 15 years (1993-2008). *J R Coll Physicians Edinb.* 2011;41(2):163-168.
16. Sleith C. Methodology checklist 3: cohort studies. *SIGN 50* 2012; https://www.sign.ac.uk/checklists-and-notes.html. Accessed August 24, 2018.
17. Sleith C. Notes on the use of Checklist 3 – Cohort Studies. *SIGN 50* 2012; https://www.sign.ac.uk/checklists-and-notes.html. Accessed August 24, 2018.
18. Baker A, Young K, Potter J, Madan I. A review of grading systems for evidence-based guidelines produced by medical specialties. *Clin Med (Lond).* 2010;10(4):358-363.
19. Irving M, Eramudugolla R, Cherbuin N, Anstey KJ. A Critical Review of Grading Systems: Implications for Public Health Policy. *Eval Health Prof.* 2017;40(2):244-262.
20. Hopkins W. A scale for magnitudes for effect statistics. *A New View of Statistics* 2002; https://www.sportsci.org/resource/stats/effectmag.html. Accessed August 23, 2018.
21. du Prel JB, Hommel G, Rohrig B, Blettner M. Confidence interval or p-value?: part 4 of a series on evaluation of scientific publications. *Dtsch Arztebl Int.* 2009;106(19):335-339.
22. Knapik JJ, Cosio-Lima LM, Reynolds KL, Shumway RS. Efficacy of functional movement screening for predicting injuries in coast guard cadets. *J Strength Cond Res.* 2015;29(5):1157-1162.
23. Dorrel B, Long T, Shaffer S, Myer GD. The Functional Movement Screen as a Predictor of Injury in National Collegiate Athletic Association Division II Athletes. *J Athl Train.* 2018;53(1):29-34.
24. Hägglund M, Waldén M, Ekstrand J. Previous injury as a risk factor for injury in elite football: a prospective study over two consecutive seasons. *Br J Sports Med.* 2006;40(9):767.
25. Knapik JJ. The importance of physical fitness for injury prevention: part 1. *J Spec Oper Med.* 2015;15(1):123-127.
26. Twitchett E, Brodrick A, Nevill AM, Koutedakis Y, Angioi M, Wyon M. Does physical fitness affect injury occurrence and time loss due to injury in elite vocational ballet students? *J Dance Med Sci.* 2010;14(1):26-31.