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Functional movement screening: A study on efficacy in predicting sport-related injuries in collegiate athletes

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Functional Movement Screening: A Study on Efficacy in Predicting Sport-Related Injuries in Collegiate Athletes

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Introduction

The functional movement screen (FMS™) is a tool used by athletic trainers, physical therapists, and fitness professionals to identify muscle imbalances and movement limitations that may lead to injury or restrict performance in physically active subjects.[1,2] The FMS™ consists of seven different movements which place the body in positions that expose muscle and movement imbalances if correct stability and mobility are not used.[1] These seven primitive motions of the human body are often lost as maturation occurs. Due to disuse, improper use, or overuse, these imbalances become more pronounced, resulting in movement deficits. When present, these deficits may be associated with risk of injury while participating in athletics.[1,2] As each of the seven FMS™ movements is performed by an individual, it is rated on a 0-3 scale for a total potential score of 21.[2] Athletes scoring less than 15 are predicted to be at a higher risk for injury.[3]

To be a valuable predictor of injury, reliability of the FMS™ must be established. Several studies have demonstrated good inter- and intra-rater reliability of the FMS™ when administered by raters with varying levels of experience.[4-7] In athletic trainers experienced in FMS™ screening, reliability resulted in an intraclass correlation coefficient (ICC) of 0.946 using a 95% confidence interval (CI) of 0.684-0.991.[4] When inexperienced FMS™ raters were compared to experienced evaluators, an ICC of 0.91 with a CI of 0.78-0.96 was found.[5] Inter- and intra-rater reliabilities of novice raters were found to be 0.76 and 0.74 with 95% CI of 0.63-0.85 and 0.60-0.83 respectively.[6,7] When compared to the high reliabilities of experienced raters[4,5], novice raters showed slightly lower inter- and intra-rater reliabilities[6,7] but are still considered acceptable for reliability of the FMS screening.

As a reliable test, the FMS™ can be used as an objective measurement to indicate progress in regard to imbalances or asymmetries.[8] When corrective exercises are implemented to improve asymmetries specific to an FMS™ movement, relevant scores will then improve.[8] Kiesel et al[8] conducted baseline FMS™ testing and placed professional American football athletes on individualized corrective interventions which complimented traditional off-season strength training. The interventions resulted in increased FMS™ scores and decreased biomechanical and muscular asymmetries after seven weeks.[8] Although decreased asymmetries may result in improved scores, research has yet to demonstrate either its effects on sport-specific performance, or if the improved scores result in a decreased risk of injury.

Kiesel et al[3,8] were the first to suggest that a score of less than 15 indicates increased risk of injury when they concluded that an FMS™ score of less than 15 indicated an 11-fold chance of sustaining a serious injury. Since then, others have used this cutoff score when studying adolescent sports[7] and military officers.[9,10] However, this score was determined in relation to males.[3,8] Only one study investigated the use of the FMS™ in collegiate female athletes.[11] Limiting FMS™ injury prediction to lower extremity injuries, Chorba et al[11] found that a score below the cutoff point of 15 resulted in a 4-fold increased risk of injury. Females are however at a higher risk of overuse injuries than males, potentially due to structural and biomechanical differences between females and males.[12] With this increased risk in female athletes[12], when compared to male athletes, there is a need for research on the gender-specific predictive capabilities of the FMS™ and the cutoff score of 15.

Taking into consideration the heightened prevalence of overuse injuries in females, there is little research indicating the FMS™ relevance to specific types of injuries. It is believed that the FMS™ may be more valuable in identifying risk of overuse injuries than in identifying risk of acute injuries.[10] O'Connor et al[10] investigated this hypothesis and found that with male military officers, an FMS™ score of less than 15 did not result in an increased risk of an overuse injury separate from an acute injury. Additionally, as the given purpose of the FMS™ is to expose imbalances, the structural and biomechanical differences between males and females will theoretically be exposed in an FMS™ score improving predictive capability with regard to female chronic injuries.[12] Therefore, the FMS may be more valuable in identifying risk of an overuse injury specifically in the female population.

Current research is limited in regards to the number of studies addressing the validity of using scores below 15 as an indicator of injury risk. Three studies included larger sample sizes numbering above 100, but most studies include small sample sizes with focused sample groups.[3-11,13,14] In two studies, sampling 874 male military recruits, correlations between FMS™ scores were evaluated in regard to injuries.[9,10] With a large sample size, these studies focused solely on male officers.[9,10] In a third study, focusing on both male and female students, a sample of 100 students found a 4.7 fold increase in risk of injury with a score below 17.[13] Determining a cutoff score of 17, this study potentially provided a new predictive score.[13] However, by including both males and females, the data failed to account for biomechanical differences between genders.[12,13] One study investigated the need for corrective exercise programs in weak links of the kinetic chain, utilizing the FMS™ to identify functional limitations in 43 female soccer players.[14] Although Grygorowicz et al[14] studied only female athletes, their research did not aim to determine the significance of 15 as a significant score, and was comprised of only soccer athletes. In a sample of 38 Division II women's soccer, volleyball, and basketball athletes, FMS™ was found effective in identifying compensatory movement patterns in female athletes which may lead to increased risk of injury.[11] This research included moderate- to high-contact sports, but neglected non-contact sports.[11] Non-contact sport injuries typically consist of overuse injuries, which may be better predicted by FMS™ than the acute injuries more commonly found in contact sports.[10] Overall, little research has been done to determine the significance of an FMS™ score of less than 15 in a comprehensive, multi-sport, female-focused sample.

Therefore, the primary purpose of this study is to determine if the FMS™ score of 15 correlates with injuries sustained in Division I female collegiate athletes in a cross sample of sports considered both contact and non-contact, as well as those comprising of team and individual sports. Secondarily, we examined the use of FMS™ scores to predict any injury, acute injuries, and chronic injuries.

Methods

FMS™ scores and injury data were retroactively extracted from pre-participation physical examinations from the 2012-2013 school year. A convenience sample of 105 female collegiate Division I athletes participating in soccer, lacrosse, volleyball, track and cross country, swimming and diving, and tennis were included. These sports were selected as a cross-section of team and individual sports where injury trends may differ across sports due to level of contact. Institutional Review Board approval was obtained to extract this data from the medical records systems for comparison purposes prior to the start of the study. Every athlete agreed, upon entry into the University's athletic programs, to allow medical information to be used for educational purposes, thus no additional consent forms were required.

All athletes on the above listed team rosters for the year were included in the study, despite previous injury history. No subjects were placed on corrective exercise programs during the course of the year to improve FMS™ scores. Recorded injuries were extracted from the electronic medical record system used by the athletic department for comparison to the FMS™ scores. An injury was defined as a musculoskeletal problem for which the athlete sought advice or treatment from an athletic training student, certified athletic trainer, or the team physician and was deemed significant enough to warrant entry into the medical records system. Injuries were then further defined as either acute (if there was an identifiable and finite mechanism of injury) or chronic (if there was no specific mechanism or incidence).

Screening was completed by two trained and experienced FMS™ evaluators who had completed the FMS™ Certification course. Screenings proceeded, using the seven FMS™ movements; deep squat, hurdle step, in-line lunge, shoulder mobility, active straight leg raise, trunk stability push-up, and rotary stability. Athletes were given a score between 0-3 for each movement: 0 for the presence of pain during movement; 1 for an inability to complete movement; 2 for imperfect completion of the movement; and 3 for perfect completion of the movement based on guidelines provided by Cook.[1,2] On tests where right and left sides are scored independently, the lower of the two scores is used in the calculation of the overall score. Overall scores can range from 0-21 with the higher scores suggesting better movement patterns. When following these guidelines, other researchers have found inter- and intra-rater reliabilities ranging from 0.74 to 0.96 suggesting very good to excellent reliability when administered by trained FMS™ raters.[4-7]

Data was entered into an excel spreadsheet, designating both raw and total FMS™ scores as well as numbers of injuries sustained. A regression analysis was used to determine if the raw FMS™ scores predicted risk of injury. Second, a correlation of the raw score to the total number of injuries sustained was computed. Total FMS™ scores were then dichotomized into two groups, 14 and below or 15 and above. Kiesel et al[3] previously identified a cut-off score of 15 or above or 14 and below as both sensitive and specific for identifying risk of injury. Injury data consisted of the total number of both acute and chronic injuries sustained by each individual. These were then combined to identify total number of injuries and dichotomized into "any injury" or "no injury" for total number of injuries, acute injury and chronic injury. The dichotomized variables were placed into 2x2 contingency tables using scores of 15 and above or 14 and below, and those who incurred an injury vs. those who did not incur an injury. This was repeated for acute and chronic injuries. Odds ratios with confidence intervals set at 95% were calculated from this data.

Results

The mean FMS™ scores of all participants was 15.48 (±1.66) with a range of 11-19 (Table 1). There was not a significant correlation (r=-.082, p=.405) between the total number of injuries sustained and total FMS™ scores. Linear regression using FMS™ total score as the independent variable and risk of an injury occurring as the dependent variable also did not result in significance ($F_{(1,104)}$=3.53, p=.063) with an R^2 of .033. Therefore, the FMS™ scores were dichotomized into 14 and below and 15 and above. Descriptive statistics with dichotomized FMS™ scores and the number of injuries and the dichotomized variables are included in Table 2. Fifty-nine percent of the athletes reported at least one injury that required evaluation and/or treatment. Thirty percent of the athletes reported at least one chronic injury with almost 50% reporting at least one acute injury. Of those who scored below 15 on the FMS™ screening, 35% suffered a chronic injury while 62% experienced an acute injury. Of those who scored 15 or above on the FMS™, the percent experiencing chronic (29%) and acute (46%) injuries was lower. The 2x2 contingency tables (Tables 3-5) show that athletes with an FMS™ score of 14 or below had a 2.272 increased risk of injury (95% confidence interval (CI) = .859-6.014) when compared to those with a score of 15 or above (Table 6). When injuries were divided into chronic and acute injuries, those with an FMS™ score of 14 or below were 1.911 times more likely to experience an acute injury (95%CI = .773-4.727) and 1.289 times more likely to experience a chronic injury (95%CI = .502-3.308) than those who scored 15 or above on the FMS™ screening. However, when confidence intervals cross over the number 1, such as ours do, it suggests that any increased risk is not considered significant.

Discussion

This study aimed to determine whether the previously established significance of an FMS™ score of less than 15 predicting risk of injury in collegiate female athletes and to study the efficacy of FMS™ in predicting any injury, acute injuries, and chronic injuries. Our results are not consistent with what others have found in previously published studies. The hypothesis that the score of 15 and above produces a significantly decreased chance of injury was not supported in this study in regard to any classification of injury. The data in this study also fail to support a clear relationship between FMS™ score and chronic or acute injuries.

One factor potentially impacting the lack of significance found in this study, when compared to other studies of female collegiate athletes, is our slightly higher mean of FMS™ scores (Table 1).[5,7,11] Subjects in this study were included regardless of injury history, pain, or imbalance on the day of screening. Previous studies have excluded individuals who met these criteria, potentially causing an inflation of their mean scores.[11,13,14] However, our mean score was higher than previous studies' data, even with our potentially deflated mean scores. The higher mean scores at baseline in our study may diminish the predictive value of the FMS™. Perhaps the skill of Division I athletes results in an increased ability to avoid injury when compared to Division III athletes. With the subjects included in this study, a higher cutoff point may be necessary to have the same predictive value found in other studies. One study implemented a higher cutoff point of 17, showing that a physically active student, male or female, has a 4.7 fold increased risk of injury with a score below 17.[13] However, further study is needed to determine if there is a better cutoff point specifically for female Division I athletes.

With an odds ratio value greater than 1, conclusions could be drawn from the data to say that all three injury categories (any, acute, or chronic) are more probable with an FMS™ score of 14 or less (Table 6). There certainly is a trend suggesting that athletes who score 14 and below on the FMS are at greater risk of injury than those who score 15 or higher. However, when confidence intervals cross over 1, as seen in our data, the probability of the odds ratio values becomes null, and suggests that the risk of injury fails to reach significance (Table 6). This held true for any injury, chronic injury, and acute injury occurrence. In previous research which attempted to establish significance of the score of 15, the relative risk and odds ratios reported showed a similar trend, as did the confidence intervals. While the risk and odds may suggest the athletes are a greater risk of injury, the conclusions drawn from these studies fail to interpret this crossing of 1 as a nullification of significance.[9-11]

The identification of the scores of 14 and below or 15 and above as indicators of increased or decreased risk for injury respectively also needs to be considered. The first study defined an injury differently than our definition. These researchers defined injury as any injury resulting in an athlete's presence on the injured reserve list for at least three weeks and mostly included severe, acute injuries due to the nature of their definition.[3] This study, as well as others[11] used the term injury to refer to a documented musculoskeletal abnormality for which advice or treatment was sought. With the term serious injury, the first study may have excluded less traumatic, chronic injuries that still affect players' top performance, while not requiring them to be placed on injured reserve for three weeks or greater.[3] This difference in injury definition may account for a lack of significance in this study when compared to earlier studies. By including chronic injuries and acute injuries of less severity in our study, our injury data was robust with various types of injuries, leading to a larger number of injuries. This may have reduced the sensitivity of the statistical analysis making the FMS™ tool less predictive than in other studies. When only severe injuries were included, an FMS™ significance score was determined based on potentially uncontrollable and unrelated factors to the biomechanical deficiencies identified in the screening.[3] It is difficult to identify if the score of 14 and below is the best indicator of injury when multiple definitions of injury are included in the research and when not all injuries included are due to biomechanical deficits.

Perhaps, future research should consider whether or not FMS™ scores correlate with injuries resulting from external or internal factors. Internal factors that may contribute to increased risk of injury, such as weak gluteus medius muscles, tight hamstring muscles or previous injury, are more like to become apparent in a movement screening. External injury factors such as shoe wear, practice surface, and collision with other athletes, while likely to contribute to injury, cannot be accounted for in an FMS™ screening. Potentially, researchers need to reconsider how injuries occurred (internal vs. external factors) when investigating the use of an FMS™ screening tool to predict injury.

Conclusion

No relationship was found between FMS™ scores and injury risk of any type in Division I collegiate female athletes. Although trends exist which suggest potential relationships, female collegiate athletes who score below 15 on an FMS screening should not necessarily be considered at an increased risk of injury through participation in sport. These investigations should consider the definition of what constitutes an injury, as not all injuries are due to intrinsic, muscle, and movement based deficits. Perhaps comparing a select FMS test (squats), or a battery of tests (all lower extremity tests), to specific injury types (ACL) or locations (lower extremity injuries) might result in a better predictive tool. While there is no doubt the FMS tool is valuable for the identification of less than optimal movement patterns and muscle imbalances that may lead to injury, further investigation must be done to verify the previously established significance of a score of 15 in regard to this specific group of athletes.

Tables

Table 1: Mean FMS™ Score Data

	Mean	Number of Participants	Standard Deviation	Range
Any Injury	15.48	105	1.66	11-19

Table 2: Descriptive Statistics.

		Number of Participants	Any Injury	Chronic Injury	Acute Injury
FMS Score	14 and Below	N=26 (25%)	19 (73%)	9 (35%)	16 (62%)
	15 and Above	N=79 (75%)	43 (54%)	23 (29%)	36 (46%)
	Total	N=105 (100%)	62 (59%)	32 (30%)	52 (49.5%)

Table 3: Any Injury Contingency Table

Any Injury		
	No	**Yes**
14 and Below	7	19
15 and Above	36	43

Table 4: Chronic Injury Contingency Table

Chronic Injury		
	No	**Yes**
14 and Below	17	9
15 and Above	56	23

Table 5: Acute Injury Contingency Table

Acute Injury		
	No	**Yes**
14 and Below	10	16
15 and Above	43	36

Table 6: Odds Ratio (OR) and Confidence Intervals (CI)

	OR	95% CI
Any Injury	2.272	(.859 to 6.014)
Chronic Injury	1.289	(.502 to 3.308)
Acute Injury	1.911	(.773 to 4.727)

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