Functional Movement Screen Normative Values
and Injury Prevalence Among Division I Athletes

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Carrie L. Docherty, Ph.D., ATC

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Robert Chapman, Ph.D.
The primary purpose of this study was to establish reference data for the Functional Movement Screen (FMS) using a large number of high-level Division I athletes from a variety of sports. Additional aims were to look at FMS performance differences between non-injured and injured athletes as well as between genders. 305 (171 females and 134 males) subjects, between the ages of 17 and 25, were recruited from a division I institution’s athletics programs. Subjects were asked to wear athletic shorts, a fitted athletic shirt, and athletic shoes. All subjects completed the seven FMS tests (Deep Squat, Hurdle Step, In-Line Lunge, Shoulder Mobility, Active Straight-Leg Raise, Trunk Stability Push-Up, and Rotational Stability). Each test was performed a maximum of three times and the highest score was used as the final score for that test. The FMS tests were evaluated on a four-point grading scale, 0-3, with a possible total score of 21. The mean total score for all athletes in this study was 16.7±1.9, with the lowest score received being 10 and the highest received was 21. The lowest average composite score of the 11 included athletic teams was 15.7±1.8. Of the athletes we tested, 43% sustained an injury during the follow up period. T-tests were used to compare differences in total FMS score between the non-injured and injured athletes as well as between males and females. We found no significant difference in total FMS score between the injured athletes (16.5±2.0) and the non-injured athletes (16.7±1.8). There was no significant difference between total FMS scores of males (16.7 ±1.7) and females (16.9 ± 1.9). We used a Receiver Operator curve (ROC) to calculate and identify if a particular total score could maximize sensitivity and specificity. The ROC curve identified the area under the curve as .51, indicating that there wasn’t a total FMS score for this population to predict whether or not an athlete is more at-risk of sustaining an injury. 96% (295/305) of the subjects in this study received an
FMS score ≥14. Fourteen has been the traditionally referenced cut off score, meaning scores below 14 theoretically identify athletes more likely to sustain an injury. Out of all recorded injuries, 97% (126/130) of injuries were sustained by subjects who scored ≥14 for the total FMS score. Using the results from this study, attempts to find another FMS score to serve as a cut off value were unsuccessful. In conclusion, the overwhelming majority of subjects in this study scored above the traditional cut off value of 14. Differences between FMS scores of non-injured and injured athletes were insignificant; the same is true between males and females. These findings suggest utilizing any total FMS score, not just the traditionally referenced value of 14, as an injury predictor is ineffective for this subject population.
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Introduction

The Functional Movement Screen (FMS) is an evaluation tool that attempts to assess the fundamental movements of an individual.\textsuperscript{1,2} The screen is comprised of 7 tests that utilize the development of functional movement to enable assessment of asymmetry, neuromuscular coordination during acceleration and deceleration, trunk and core stability and strength, as well as (dynamic) flexibility and (dynamic) balance.\textsuperscript{1-3} The tests were designed to provide observable performance of basic locomotor, manipulative, and stabilizing movement.\textsuperscript{4} The FMS provides a means of immediate feedback to be used by the patient and clinician for implementation in a training program. The seven tests that make up the FMS include: Deep Squat, Hurdle Step, In-Line Lunge, Shoulder Mobility, Active Straight-Leg Raise, Trunk Stability Push-up, and Rotary Stability.\textsuperscript{1,2}

The creators, Gray Cook and Lee Burton, designed the FMS to identify limitations or asymmetries in the basic movement patterns of physically active individuals that can hinder athletic performance and potentially identify individuals at-risk for sustaining an injury.\textsuperscript{1,4} From a health care perspective, utilization of screening tools have the potential to assist in identifying biomechanical deficits which can be addressed prior to an injury actually occurring.\textsuperscript{1,5,6} Other screens have been created, but tend not to meet the specific needs of each athlete.\textsuperscript{1} The FMS can offer the foundation for determining and prescribing appropriate proactive interventions for the athlete.\textsuperscript{1,7} Changing or modifying identified inherent faulty movement patterns may serve to decrease the risk of sustaining an injury by improving stabilization and/or mobility deficits.

The FMS focuses on the efficiency of movement patterns rather than the number of times you can complete a given task or the amount of weight lifted.\textsuperscript{8} The FMS measures the quality of the movement for each test based on specified criteria which utilizes a 4-point scale.\textsuperscript{1} A higher score indicates better performance on the movement pattern. Five of the seven FMS tests are
scored separately for the left and right sides. The lower score of the two sides is used as the final score for that test, but having a score on each side allows us to identify asymmetries in an athlete and how these may be a potential risk factor for future injury.\cite{1,2,5} A combined total FMS score can be calculated by adding the scores for all the tests together. This creates a maximum value of 21.\cite{1}

FMS research concerning inter- and intra-rater reliability has found strong to excellent results are possible for both novice and experienced clinicians alike.\cite{9-13} However, the limited published work that has been done on how the FMS scores translate to risk of injury is mixed. Initial work by Kiesel et al.\cite{5} utilized a Receiver Operator Characteristic (ROC) curve to identify the value which maximized both the specificity and sensitivity of the FMS. It was found that individuals that had a total score <14 were theoretically more at-risk to sustaining an injury compared to those who scored ≥14.\cite{5} However, this study\cite{5} was limited to a small number of football athletes (N=46), so the ability to generalize this conclusion to other athletes is unknown. The FMS has been utilized among the general middle-aged population\cite{7,14}, military personnel\cite{15}, career firefighters\cite{3}, and various sports teams at different competitive levels.\cite{15-22}

To date, studies concerning division I athletes have focused on select teams with smaller number of subjects. The purpose of this study is to help establish normative values for high level athletes using a larger sample population from members of multiple division I athletic teams. Establishing reference values for different sports and genders would enhance the use of the FMS among strength coaches, physical therapists, and athletic trainers. We also determined if a composite FMS score differences between injured and non-injured, or if there is an appropriate cut-off to determine which athletes might be predisposed to sustaining an injury.

**Methods**

Utilizing a prospective cohort study design, we obtained FMS scores from Division I university male and female athletes. One of two evaluators screened the athletes, 229 were
screened by the first evaluator and 76 were screened by the second examiner, using the standard FMS kit. The evaluators had good to excellent inter-reliability (ICC=0.82). Injury records were tracked over a 12-month period, following the FMS screen, using Sports Injury Monitoring System Software (SIMS) (Flantech computer services, Iowa City, IA, version 7.0). The 12-month follow-up period consisted of one in-season and one off-season semester for each athlete. For the purpose of this study, an injury was defined as: the inability of an athlete to participate in practice or competition for at least one full day after the initial onset. Also, the injury must have occurred as a result of participation in an organized intercollegiate team practice, strength and conditioning session, or competition. The injury also had to be recorded in the SIMS system showing athlete has undergone rehabilitation treatment. Every athlete in this study could only account for one injury in the data.

Subjects

305 subjects (171 females and 134 males) are included in this study (See Table 1 for demographic information). An athlete is defined as being on roster of one Division I team for at least a 12-month period that had an in-season and off-season period. Specific data related to sport participation is located in Table 2. Exclusion criteria included having a current orthopedic injury or damage to any bony, ligamentous, or soft tissue structures at the time of FMS testing. We also excluded participants if they were concussed or had any current illness or ailment that may impact balance or coordination, thus affecting results. All subjects read and signed an informed consent form approved by the University’s Institutional Review Board for the Protection of Human Subjects.

FMS Procedures

All subjects performed the tests in the same order: Deep Squat, Hurdle Step, In-Line Lunge, Shoulder Mobility, Active Straight-Leg Raise, Trunk Stability Push-Up, and Rotational Stability. All
tests were scored on the a four point scale, 0-3, with a maximum combined total score of 21 possible. Each test was performed a maximum of three times. For tests that were scored bilaterally, each limb was allowed three attempts and the lowest of scores of the two limbs was record for the final score of that test. Athletes earned a score of zero for pain, a score of one if unable to complete movement, a score of two for completion of movement with compensations, and a score three for completion of movement without any compensations.

Deep Squat

The starting position for the deep squat is assumed when the subject has their feet approximately shoulder width apart and feet facing forward in the sagittal plane. The subject first held the dowel overhead with elbows flexed approximately 90°, then maximally pressed the dowel upward with shoulders flexed and abducted while elbows were extended. Facing forward with heels on the ground and keeping the dowel pressed overhead, the subject was instructed to squat as low as possible in a controlled manner. Three attempts were allowed for a score of three to be earned, if the subject can complete the movement. If the subject could not complete the movement in the first three attempts, a 2x6 board was then placed under the heels to eliminate the dorsiflexion aspect. A score of two was earned if the subject was then able to complete the movement with the 2x6 board. A score of one was given if they were still unable to do so.

Hurdle Step

The hurdle step followed next and was performed bilaterally with a maximum of three attempts on either side. The hurdle height was adjusted based on the length of the subject’s tibia, measured at the tibial tuberosity. The starting position consisted of the subject’s feet together with toes touching the base of the hurdle with the dowel held across the shoulders below and behind the neck. While looking straight ahead the subject was then instructed to slowly step over
the hurdle and touch their heel to the floor before slowly returning to start position. The subject needed to maintain a stable upright torso and the lower extremity needed to be kept in alignment in the sagittal plane as the dowel and hurdle string remain parallel. The moving leg was scored as the stance leg maintained an extended position. A score of three was earned if the subject was able to perform one repetition meeting criteria. A score of two was given if lower extremity alignment was lost, movement was noted in the lumbar spine, or if the dowel and string did not remain parallel. A score of one was given if contact was made between the feet and hurdle string or if balance was lost at any time.

_In-Line Lunge_

For the in-line lunge the subject was instructed to step on a tape measure or on the 2x6 board with half-inch increments. The tibia height, gained from the hurdle step test, was the distance between the back foot’s toes and the front foot’s heel. The subject then held the dowel behind his/her back while maintaining contact with the head, thoracic spine, and sacrum. The hand opposite the front foot held the dowel behind the subject’s neck, the other grasps the dowel in the small of the lumbar spine. The subject was then instructed to slowly lunge straight down and attempt to touch the back knee on the surface directly behind the front foot before returning to the top position. The in-line lunge is performed up to three times bilaterally. A score of three was earned when the dowel remains in contact, there was no torso movement, dowel and feet remained aligned in sagittal plane as the knee touched the board behind front heel. A score of two was given if subject could perform the lunge but did not meet all criteria for a score of three. A score of one was given if balance was lost at any time.

_Shoulder Mobility_

The shoulder mobility test was performed bilaterally up to three times. Hand length was first attained measuring from the tip of the third digit to the most distal crease of the wrist. The
subject was then asked to make a fist with both hands while placing the thumb inside the fist. The subject was then instructed in one smooth motion to simultaneously move one fist down the back and the other up the back. This placed one shoulder in a maximal adducted, extended, and internally rotated position and the other in a maximal abducted, flexed, and externally rotated position. Using the subject’s hand length, the examiner measured the distance between to two closest points on either hand. The shoulder that was flexed (fist moving down the back) was the side being tested. A score of three was earned if the fists were within one hand length from each other. A score of two was given if the fists were within one and a half hand lengths. A score of one was given if the fists were more than one and a half hand lengths apart.

**Active Straight-Leg Raise**

The starting position for the subject performing the active straight leg-raise is laying flat supine, toes pointed upward, and knees extended effectively pinning the 2x6 board to the ground underneath. This test was performed up to three times bilaterally. The examiner placed the dowel, perpendicular to the floor, at the mid-point between the anterior superior iliac crest and mid-point of the patella. With a dorsiflexed ankle and extended knee, the subject was instructed to lift the leg thru to the end range by flexing the hip to move the ankle beyond the dowel. During this test the subject’s head should remain flat and the opposite leg must remain in contact with the ground while not externally rotating. A score of three was earned when the subject’s ankle clears the dowel in its original position. A score of two was given when the dowel needs to be moved, midway between mid-thigh and patella, for the ankle to clear. A score of one was given when the subject is unable to clear the dowel when it is midway between mid-thigh and patella.

**Trunk Stability Push-Up**

The starting position for the trunk stability push-up is a prone position with the subject’s feet together, ankles dorsiflexed, and knees extended. The subject’s hands were then positioned
shoulder with apart, with thumbs aligned with the forehead for men or with the chin for women. A score of three was earned if the subject can perform the push-up from this starting position. A score of two was given when hands need to be realigned, with the chin for men or the clavicle for women, in order to do the push-up. A score of one was given when the subject was unable to perform the push-up with hands in the realigned positions.

*Rotary Stability*

For the rotary stability test the subject assumed a quadruped position with shoulder, hips, and knees at 90°, and the ankles dorsiflexed. The 2x6 board was on the ground and pinched between the hands, knees, and feet. From this position the subject then flexed the shoulder and extended the hip and knee on the ipsilateral side, aiming to clear the ground by 6 inches. From there the subject extended the shoulder and flexed the hip and knee so contact could be made between the elbow and knee, before returning to start position. This test is scored bilaterally for the upper extremity performing the movement. A score of three was earned when the subject completes the movement while keeping the spine parallel to the ground. A score of two was given when the subject performed the diagonal pattern, touching opposite elbow and knee, while keeping spine parallel to the ground. A score of one was given if the subject was unable to perform the diagonal pattern.

*Statistical Analysis*

We calculated final scores by adding the values from the seven tests. We divided subjects into groups based on gender, sport, and whether or not they sustained an injury during the study period. We used t-tests to compare differences in total FMS score between the non-injured and injured, male and females, and sports. Cross tabulations were also calculated to identify the
frequency of total FMS scores in the injured and uninjured groups. We used a Receiver Operator curve (ROC) to calculate and identify if a particular total score would maximize sensitivity and specificity. Similar to previous research, the ROC curve was used to determine if a particular score could differentiate athletes predisposed to sustaining an injury. Alpha level for all analysis was set a p<0.05.

Results

Out of the total of 305 participants, 130 sustained an injury during the study period (43%). Descriptive information for the type of injuries sustained by the athletes is located in Tables 3 and 4. We identified no significant difference between the injured (16.5±2.0) and uninjured (16.7±1.8) athletes for the total FMS score (t_{303} = .70, p = .49, ES=.08, Power=.30). There was also no significant difference found between males (16.6±1.8) and females (16.7±2.1) for the total FMS score (t_{303} = .46, p = .64, ES = .05, Power = .30). Total FMS score and injury status cross tabulations are located in Table 5. ROC analysis identified the area under the curve as .51, indicating that the total FMS score does not help to predict whether or not an athlete is more at-risk of sustaining an injury.

Discussion

The FMS is an evaluation tool that utilizes fundamental movement patterns to assess individuals for injury prevention and performance predictability. To date, there are no known normative value studies utilizing the majority of an athletic population, across multiple sports, at a Division I institution. The primary purpose of this study was to establish reference data using a large number of high-level Division I athletes from a variety of sports. Additionally, we thought it was important to determine if the previously established cut-off score was applicable for the athletes in this study.
The mean total score for all athletes in this study was 16.7±1.9, with the lowest score received of 10 and the highest received was 21. Further, when evaluating the individual sports, no mean total score for any one sport was lower than 15.7±1.8. See table 6 for specific values by sport. These findings were comparable to other studies that utilized collegiate athletes.\textsuperscript{16,17} One study on Division I track and field athletes found no significant difference in total FMS scores between non-injured (15.6 ± 2.7) and injured (15.9 ± 1.8).\textsuperscript{16} Injured athletes on average had slightly higher total FMS scores than the non-injured, as did track and field and cross-country athletes in the present study (Table 6). A study of females on Division I basketball (15.74±1.86), soccer (16.92±1.02), and volleyball (17.36±1.22) teams also found no significant difference in FMS scores between non-injured (16.86±1.56) and injured (16.08±1.12) athletes.\textsuperscript{17} The present results and previous findings suggest that using composite FMS scores alone may not be effective for identifying athletes at increased risk of injury. The previous study on Division I female athletes used an ROC curve that identified 16.5\textsuperscript{17} as an ideal cut off value, whereas the track and field study was unable to identify an ideal score.

Of the athletes we tested, 43% sustained an injury during the follow up period. Among included athletes it was found that the injured athletes (16.5±2.0) had a similar mean total FMS score than the non-injured athletes (16.7±1.8). These comparable means suggest that the present FMS scoring criteria/scale isn't specific enough to be indicative of which athletes may sustain an injury. For this study population, a cutoff using a total FMS score of 14 was not adequate for identifying athletes at risk of sustaining an injury. Over 96% of athletes in this study received a total FMS score ≥14. Out of all recorded injuries, 97% (126/130) were sustained by subjects had scored ≥14 for the total FMS score (See table 4). An ROC curve was run to attempt to identify a better cutoff total score for the FMS, however no score could be statistically identified that would be better than simple chance.
Several previous studies evaluated only the deep Squat when determining if an athlete may become injured. As the deep squat test is a total body movement, coordination of strength and mobility throughout the entire kinetic chain is necessary for successful completion.\textsuperscript{6,23} A biomechanical analysis of the deep squat by Butler et al\textsuperscript{23} found that for those who received a 1, 2, or 3 on the deep squat, there were differences in peak joint angles, joint angle excursion, and peak joint moments at the ankle, knee, and hip. However, the 4-point scoring scale used for the FMS makes it difficult to differentiate real-time performance faults between individual scores, not only on the deep squat, but for all 7 FMS tests. In the current study, individuals who sustained an injury scored an average of a 2.3 (SD = 0.6) on the Deep Squat while individuals who did not sustain an injury scored an average of 2.5 (SD = 0.5).

When considering the rotary stability test, 92\% (281/305) of the athletes in this study earned a score of 2. Earning a 3 on the rotary stability clearly distinguishes higher performance, but a specific criterion is lacking to differentiate performance between the 281 athletes that earned a score of 2. This questions the usefulness of including the rotary stability test with the 4-point scoring scale.

The 4-point scoring scale makes grading simple for the clinician at the cost of specificity identifying the underlying problem. One of the only known studies to explore alternative scoring criteria utilized a 100-point scoring scale (instead of 21) using videotaped performances for the 7 FMS.\textsuperscript{24} For this study 100-point FMS scores the quality of movement on a continuum from being unable to complete any component of the movement to the maximum score indicating one complete repetition of the functional movement pattern without compensation or substitution.\textsuperscript{24} Overall reliability for this study was excellent. However, the assessments were video-based rather than real-time for this initial study of the 100-point scale. Further research on real-time application is necessary if this scoring scale, or any other, is to be implemented on a regular basis.
Secondary Purpose

For the secondary aim of this study, there was also no significant difference between total FMS scores of males (16.7 ± 1.7) and females (16.9 ± 1.9). However, significant differences were found between males and females on four individual FMS tests for this study. Males performed better on the trunk stability push-up test while females performed better on the in-line lunge, shoulder mobility, and active straight-leg raise tests. This may be attributed to the strength advantage males have when performing the push-up whereas females are likely to benefit from the flexibility necessary for the active straight-leg raise, shoulder mobility, and split-leg stance of the in-line lunge. There is only one protocol difference in the FMS between men and women: for women, starting hand placement is adjusted during the core stability push-up. Previous studies typically had a focus on one gender or lacked a significant number of subjects or injuries to draw confident conclusions from when making comparisons.

Conclusion

The results of this study show that there is no significant difference in composite FMS scores between injured and uninjured athletes or between male and female athletes. Further, no score was found to be superior than another to maximize the specificity or sensitivity of the FMS for this population.

This research is one of the first to provide data on a large Division I population from numerous sporting backgrounds. Scores on individual tests might be more indicative of who will sustain an injury. Additionally, subsequent studies should focus on the correlation between injuries and asymmetry in one of the five bilateral movement tests or between injuries and the presence of a score of 1 on any of the seven tests. If the values gained from this study can be confirmed by or compared to other Division I and active populations, future research can continue to focus on details beyond reliability and total FMS scores.
REFERENCES

19. Cuson MJ. *FMS scores as a predictor of acute lower extremity division I intercollegiate basketball players.* Toledo: Exercise Science, University of Toledo; 2010.


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<th>Subjects</th>
<th>Age</th>
<th>Height (cm)</th>
<th>Weight (kg)</th>
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<tbody>
<tr>
<td>Female</td>
<td>171</td>
<td>19.6 ± 1.3</td>
<td>169.1 ± 9.8</td>
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<tr>
<td>Male</td>
<td>134</td>
<td>19.7 ± 1.4</td>
<td>183.0 ± 8.1</td>
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<tr>
<td>Total</td>
<td>305</td>
<td>19.6 ± 1.3</td>
<td>175.2 ± 11.4</td>
</tr>
<tr>
<td>Sport</td>
<td>N</td>
<td>AGE</td>
<td>HEIGHT (cm)</td>
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<td>---------</td>
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<td>Soccer</td>
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<td>19.3 ± 1.0</td>
<td>173.7 ± 8.3</td>
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<td>Volleyball</td>
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<td>19.4 ± 1.4</td>
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<td>XC</td>
<td>12/19</td>
<td>20.5 ± 1.6</td>
<td>175.5 ± 8.7</td>
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<tr>
<td>Track &amp; Field</td>
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<td>20.1 ± 1.5</td>
<td>178.2 ± 9.9</td>
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<tr>
<td>Softball</td>
<td>14/0</td>
<td>19.4 ± 1.3</td>
<td>169.6 ± 5.9</td>
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<tr>
<td>Track &amp; Field</td>
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<td>19.1 ± 1.1</td>
<td>189.5 ± 7.9</td>
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<td>Rowing</td>
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<td>178.0 ± 9.3</td>
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<td>Wrestling</td>
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<td>178.3 ± 6.6</td>
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<td>176.5 ± 7.9</td>
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<td>Cheerleading</td>
<td>37/9</td>
<td>19.6 ± 1.3</td>
<td>162.1 ± 9.1</td>
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<td><strong>TOTAL</strong></td>
<td>305</td>
<td>19.6 ± 1.3</td>
<td>175.2 ± 11.4</td>
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### Table 3: Injuries by Location

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<th>Location</th>
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<td>No Injury</td>
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<tr>
<td>Foot</td>
<td>15</td>
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<tr>
<td>Ankle</td>
<td>21</td>
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<td>Knee</td>
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<td>Upper Leg</td>
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<tr>
<td>Back</td>
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<td><strong>Total</strong></td>
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Table 4: Injury Onset

<table>
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<td>No Injury</td>
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<tr>
<td>Acute</td>
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<td>Chronic/Gradual</td>
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<td>Total</td>
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Table 5: Cross Tabulations – Composite FMS Scores and Injury Status

<table>
<thead>
<tr>
<th>Composite FMS Scores</th>
<th>Non-Injured</th>
<th>Injured</th>
<th>Total</th>
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</thead>
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<tr>
<td>10</td>
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<tr>
<td>11</td>
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<td>2</td>
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<td>21</td>
<td>1</td>
<td>2</td>
<td>3</td>
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<tr>
<td>Totals</td>
<td>175</td>
<td>130</td>
<td>305</td>
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<tr>
<td>Sport</td>
<td>Non-Injured</td>
<td>Injured</td>
<td>Total</td>
</tr>
<tr>
<td>-------------</td>
<td>-------------</td>
<td>---------</td>
<td>--------</td>
</tr>
<tr>
<td></td>
<td>M ± SD</td>
<td>n</td>
<td>M ± SD</td>
</tr>
<tr>
<td>Soccer</td>
<td>16.5 ± 1.9</td>
<td>23</td>
<td>16.9 ± 2.0</td>
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<tr>
<td>Volleyball</td>
<td>17.0 ± 2.1</td>
<td>9</td>
<td>15.3 ± 2.1</td>
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<tr>
<td>XC</td>
<td>16.4 ± 1.8</td>
<td>15</td>
<td>17.2 ± 2.0</td>
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<tr>
<td>T&amp;F</td>
<td>17.1 ± 1.7</td>
<td>23</td>
<td>17.3 ± 1.9</td>
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<tr>
<td>Softball</td>
<td>17.1 ± 1.6</td>
<td>7</td>
<td>15.0 ± 1.6</td>
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<tr>
<td>Baseball</td>
<td>16.2 ± 1.5</td>
<td>21</td>
<td>16.5 ± 1.7</td>
</tr>
<tr>
<td>Rowing</td>
<td>16.5 ± 1.5</td>
<td>14</td>
<td>15.2 ± 3.1</td>
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<tr>
<td>Wrestling</td>
<td>18.0 ± 1.7</td>
<td>9</td>
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<td>Field Hockey</td>
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<td>Tennis</td>
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<td>15.0 ± 0.0</td>
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<td>Cheer</td>
<td>16.7 ± 2.0</td>
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<tr>
<td>Total</td>
<td>16.7 ± 1.8</td>
<td>175</td>
<td>16.5 ± 2.0</td>
</tr>
</tbody>
</table>
APPENDIX A

OPERATIONAL DEFINITIONS

ASSUMPTIONS

DELIMITATIONS

LIMITATIONS

STATEMENT OF THE PROBLEM

DEPENDANT AND INDEPENDENT VARIABLES

HYPOTHESIS
**Operational Definitions**

**Active Individuals** – people who minimum of 150 minutes of physical activity per week

**Active Straight-leg Raise**- Test that theoretically assesses active hamstring and gastrocnemius range of motion while maintaining a fixed pelvis and not allowing the opposite leg to lift from the ground

**Clearing tests**- The purpose of the clearing tests is to identify pain that may be a factor in the discrepancies found. If the individual has pain when performing the clearing test, that person automatically receives a zero as a score for that test.

**Discrepancies**- Imbalances shown when performing the FMS tests, compared bilaterally

**Deep Squat**- Believed that this test assesses the ability of the individual to fully dorsiflex the ankles, flex the knees and hips, extend the thoracic spine appropriately, and flex and abduct the shoulders when holding the dowel overhead

**Early Movement Milestones** – the locomotor and object-control skills that emerge before a child attains upright or bipedal locomotion. These include rolling over, crawling, creeping, sitting, standing, walking, and object manipulation, which are performed in prone, supine, sitting, or hand-and-knees positions.¹

**Fundamental Movement Skills** – the locomotor and object control skill performing in an upright, bipedal position that are used by persons in all cultures of the world. Locomotor skills include walking, running, jumping, sliding, galloping, hopping, and leaping, while object-control skills include throwing, catching, striking, bouncing, kicking, pulling, and pushing.¹

**Healthy**- Individuals who are not concussed and do not have any of illness/injury that could alter the results
**Hurdle Step** - Theorized to test functional mobility and stability at the hips, knees, and ankles

**Illness** – Any condition that may affect balance, coordination, or physical wellbeing

**Injury**- Any boney, ligamentous, or soft tissue damage that has withheld subject from participation for at least 1 full day

**In-line Lunge**- Believed to be performed to assess ankle, knee, hip, trunk, and shoulder mobility and stability

**Pattern** - the basic movement or movements involved in the performance of a particular task

**Rotary Stability**- Assesses neuromuscular control while the individual flexes the shoulder while extending the knee and hip on the ipsilateral side with minimal weight transfer to the stationary side

**Subjects**- Healthy Division I athletes, aged 18-25, who are cleared after completing the health history questionnaire.

**Scoring System**- Means of grading the quality of movement during the functional movement screen. Scores range from zero to three. The highest score an individual can receive is a twenty-one.

- **Zero score**- If the individual experiences pain anytime during the test or during the clearing assessment
- **One score**- Represents inability to complete the test
- **Two score**- Signifies completion of the test but with limitation or discrepancy
- **Three score**- Indicates that the individual performed the test without difficulty or discrepancy
**Shoulder Mobility** - Hypothesized to assess bilateral shoulder adduction with internal rotation and shoulder external rotation with abduction

**Trunk Stability Push-up** - Believed that the test assesses spinal stability in a neutral position while performing a closed-kinetic chain push-up without allowing movement in the spine or hips

**Assumptions**

The following assumptions will apply to this study:

1. The participants will have similar background in terms of activity levels
2. The participants will perform the exercises at a maximal effort
3. The participants will be honest when screening for healthy individuals
4. The participants will truthfully report any pain when performing the tests and/or the clearing examinations
5. The Functional Movement Screen will be administered according to the protocol established by Gray Cook
6. The participants will follow the instructions provided and ask if they do not understand the instructions
7. The participants will have no previous knowledge of how to complete the FMS
8. The researcher will read the instructions directly and will provide no leading clues on how to perform the exercise

**Delimitations**

The following delimitations will apply to this study:

1. 400 subjects will be tested
2. The subjects will perform the Functional Movement Screen one time, completing all seven tests during that time.

3. The tests will be given in the same order for every subject.

4. The clearing tests will be performed after the completion of the Shoulder Mobility, Rotary Stability, and Trunk Stability Push-up tests.

5. Each test will be done, at most, three times and scores will be taken from the best trial.

6. All testing will be performed by the same researcher.

7. No subjects will be concussed or have a history of being concussed within 6 months of data collection.

8. Any subjects with neurological symptoms will be excluded.

9. Any subjects with a cold or illness of any sort that alters balance will be excluded.

10. No orthopedic braces will be worn during data collection.

11. Only the FMS equipment will be used throughout the study.

12. Subjects will not exercise or warm up before performing the FMS.

Limitations

1. Asymmetry\(^2\) – Subjects may demonstrate possible right or left side dominance for bilaterally tests. Final scores for bilateral tests are taken from the lower score of the left and right sides.

2. Body Mass Index (BMI) – Higher BMI may influence (hinder) subjects’ ability to perform FMS tests.

3. Focus\(^3\) – Barring distractions, subjects attempt to complete the FMS tests to best of their ability.
4. Motor Control\textsuperscript{3} – Ability to contemplate and execute actions necessary to perform the FMS tests.

5. Previous Injury – Subjects may potentially have altered mechanics as result of a previous injury.

**Statement of the Problem**

Functional Movement Screen (FMS) is a tool used to evaluate movement patterns in order to identify discrepancies in athletes and other active individuals. The main goal of the FMS is to use the discrepancies found to determine the chance of injury for that individual. FMS is comprised of seven tests that require balance and mobility of those being tested. The tests include Deep Squat, Hurdle Step, In-Line Lunge, Shoulder Mobility, Active Straight-Leg Raise, Trunk Stability Push-up, and Rotary Stability. However, only the Trunk Stability Push-up differentiates procedure based on gender of the test subject. To date there is limited published information on normative values for the FMS. From the existing data there are no established normative values for high-level athletes, such as those at a competitive Division I institution. Therefore the purpose of this study is to establish normative values for the FMS in a population of active, healthy athletes. The secondary purpose of this study was to investigate whether performance on the FMS differed between males and females, between sports, and between athletes that did or did not sustain an injury over the course of their athletic season.

**Dependent Variables**

1. Deep Squat Test Score
2. Hurdle Step Test Score
3. In-Line Lunge Test Score
4. Shoulder Mobility Test Score
5. Active Straight-Leg Raise Test Score
6. Trunk Stability Push-up Test Score
7. Rotary Stability Test Score
8. Combined Total Score

**Independent Variables**

1. Injured vs Non-injured athletes
2. Gender, at two levels
3. Sport by 11 separate rosters

**Research Hypothesis**

1. There will be no significant difference between injured and uninjured groups
2. There will be no significant difference between sports
3. Women will score significantly better on the straight-leg raise.
4. Women will score significantly better on the shoulder mobility test.
5. Men will score significantly better on the trunk stability push-up test.

**Statistical Hypothesis**

Null Hypotheses: There will be no difference between genders:

- Combined Total Score: $H_0: \mu_{\text{Injured}} = \mu_{\text{Uninjured}}$
- Combined Total Score: $H_0: \mu_{\text{Sport 1-11}} = \mu_{\text{Sport 1-11}}$
- Deep Squat: $H_0: \mu_{\text{male}} = \mu_{\text{female}}$
- Hurdle Step: $H_0: \mu_{\text{male}} = \mu_{\text{female}}$
- In-Line Lunge: $H_0: \mu_{\text{male}} = \mu_{\text{female}}$
- Shoulder Mobility: $H_0: \mu_{\text{male}} = \mu_{\text{female}}$
Active Straight-Leg Raise   Ho: \( \mu(\text{male}) = \mu(\text{female}) \)

Trunk Stability Push-Up   Ho: \( \mu(\text{male}) = \mu(\text{female}) \)

Rotary Trunk Stability   Ho: \( \mu(\text{male}) = \mu(\text{female}) \)

Combined Total Score   Ho: \( \mu(\text{male}) = \mu(\text{female}) \)

Alternate Hypotheses: There will be a significant difference between genders:

Combined Total Score   HA: \( \mu(\text{Injured}) \neq \mu(\text{Uninjured}) \)

Combined Total Score   HA: \( \mu(\text{Sports 1-11}) \neq \mu(\text{Sports 1-11}) \)

Deep Squat   HA: \( \mu(\text{male}) \neq \mu(\text{female}) \)

Hurdle Step   HA: \( \mu(\text{male}) \neq \mu(\text{female}) \)

In-Line Lunge   HA: \( \mu(\text{male}) \neq \mu(\text{female}) \)

Shoulder Mobility   HA: \( \mu(\text{male}) \neq \mu(\text{female}) \)

Active Straight-Leg Raise   HA: \( \mu(\text{male}) \neq \mu(\text{female}) \)

Trunk Stability Push-Up   HA: \( \mu(\text{male}) \neq \mu(\text{female}) \)

Rotary Trunk Stability   HA: \( \mu(\text{male}) \neq \mu(\text{female}) \)

Combined Total Score   HA: \( \mu(\text{male}) \neq \mu(\text{female}) \)
The Functional Movement Screen (FMS) is a tool used to evaluate movement patterns in order to identify deficiencies in athletes and other active individuals. The goal of those who use the FMS is to identify any deficiencies and then to determine if these deficiencies will increase the chance of injury for an individual. By using the FMS to determine who is at a greater risk of injury, the developers of the FMS, Gray Cook and Lee Burton, hope to aid sports conditioning specialists, athletic trainers, and coaches in developing prevention programs for those athletes. In this chapter, all research pertaining to the FMS will be discussed, as well as movement patterns that have the potential make up its theoretical framework, inter-rater and intra-rater reliability using the FMS, cut-off value within the FMS to distinguish those at risk of obtaining injuries throughout a competitive season, information to predict injury and then compared that to intervention programs to see if FMS scores would change. Some have taken components of the FMS and used it as a comparative tool against other performance protocols to see if any correlation exists.

Motor Development Patterns

Motor development is the study of changes in human motor behavior that occur over a lifespan, the processes that influence those changes, and other factors that may influence these changes. The process of motor development is continuous and involves the interactions of several factors. Such factors include neuromuscular maturation, the growth characteristics, the rate of development, the lasting effects of motor memory, and new motor experiences. Cook et al. cited the need for an analysis of fundamental movement patterns in pre-participation screens. Subsequently, the FMS was developed based on these movement patterns as an evaluative option that relates closely to what an
The movements performed during activity are developed over time, beginning in infancy. The same movements and milestones are not used across various examination methods, making it hard for an overall picture of fundamental movement pattern development to be drawn from the literature. The FMS is an attempt to capture the complex construct of motor control, movement oriented tests that assess if functional movement and dynamic balance have been developed.4

Early Movement Milestones and Fundamental Movement Patterns

To determine early movement patterns, the World Health Organization (WHO) performed monthly examinations to look at the age windows for children to reach six gross motor development milestones: sitting without support, hands-and-knees crawling, standing with assistance, walking with assistance, standing and walking alone.34 Using the child’s age in months, fieldworkers recorded when a child was able to perform a task, but not necessarily the quality of the movements. This study by the WHO is significant as it included children from six geographically diverse countries: Brazil, Ghana, India, Norway, Oman and the USA.34 Trained fieldworkers collected monthly information on children ranging from four to twelve months of age and bimonthly thereafter until all milestones were achieved or the child reached twenty-four months of age. In about 90% of the cases, the pattern observed followed a fixed sequence for five of the milestones (sitting without support, standing with assistance, walking with assistance, standing alone, and walking alone).34 The windows of achievement overlap across the milestones. However, on average sitting without support occurred at 5.4 months, standing with assistance at 6.6 months, walking with assistance at 7.8 months, hands-and-knees crawling at 8.3 months, walking alone at 9.4 months, and standing alone at 10 months.34 These actions are similar to those
discussed and labeled by Burton and Miller\textsuperscript{5} as early movement milestones and are almost always acquired before fundamental movement skills.

During the first 2 years of life, independent walking is the major motor development task.\textsuperscript{31} The developmental changes leading to walking behavior are essentially a series of postural changes through which the child gains the motor control necessary to first assume upright posture, then maintain upright posture, and finally to walk independently.\textsuperscript{31} Burton and Miller\textsuperscript{1} cited that fundamental movement skills, usually developed between one and seven years of age, are the locomotor and object-control skills performed in an upright or bipedal position. The onset of walking is seen as the boundary between early movement milestones and fundamental movement skills.\textsuperscript{1}

The early movement milestones defined by Burton and Miller\textsuperscript{1} are similar to those discussed by the WHO. They are considered the movements developed in the time before a child attains upright or bipedal locomotion and include rolling over, crawling, creeping, sitting, standing, walking, and object manipulation.\textsuperscript{1} Fundamental locomotor skills include walking, running, jumping, sliding, galloping, hopping, and leaping.\textsuperscript{1} Lastly, fundamental object-control skills include throwing, catching, striking, bouncing, kicking, pulling and pushing.\textsuperscript{1} Both the early movement milestones and fundamental movement skills are referred to as phylogenetic skills because of their universal occurrence, and together are viewed as components of all specialized movement skills.\textsuperscript{1}

Proficiency in movement pattern execution has been described using terms ranging from immature to mature and from minimal form to sport skill form.\textsuperscript{31} These may be terms that can be used when trying to make a comparison between the FMS and other scales that have tried to grade movement. Assumptions of motor assessment vary among the
numerous tools according to the theoretical perspective of the developer creating the test. It is essential then that the clinician is aware of the theoretical framework behind the assessment tools they choose. That is true for both the FMS and the various infant development scales. A connection might be made as the literature hints that motor patterns may be considered mature years later when they have been developed or trained for an individual’s activity. Fundamental patterns are integrated into more complex movement sequences, such as those required for specific games and sports. This somewhat follows what Cook claims when he states his tests are more advanced versions of the fundamental movements.4,5,33

The FMS Test

The FMS is comprised of seven tests, these tests include Deep Squat, Hurdle Step, In-Line Lunge, Shoulder Mobility, Active Straight-Leg Raise, Trunk Stability Push-up, and Rotary Stability.4,5 Within each test of the FMS, the researcher must score the individual’s performance. The scores follow a four-point scale. A score of three indicates that the individual performed the test without difficulty or discrepancy.4,5,33 A score of two signifies completion of the test but with limitation or discrepancy.4,5,33 A score of one represents inability to complete the test.4,5,33 If the individual experiences pain anytime during the test or during the clearing assessment, a score of zero is given for that test.4,5,33 The scoring system applies to all seven tests and the goal for each test is to achieve a score of three. Further, some tests have modifications for the different levels of scoring.4,33 Three tests have clearing assessments that must be performed at the end of the test (Trunk Stability Push-up, Shoulder Mobility, and Rotary Stability).33 The purpose of the clearing tests is to identify pain and if pain may be a factor in the discrepancies found. If the individual has
pain when performing the clearing test, that person automatically receives a zero as a score for that test. The highest score an individual can receive on the FMS is a twenty-one.4,5

Deep Squat

The first of the seven tests is the Deep Squat. When an individual completes a deep squat, he must be able to dorsiflex the ankles, flex the knees and hips, extend the thoracic spine appropriately, and flex and abduct the shoulders when holding the dowel overhead.4 If the individual is unable to obtain a score of three, the individual performs the test again with a 2x6 plank under his heels.4 It has been seen in other studies that differences found in scores of the deep squat were caused by altered mechanics in the hips, knees, and ankles and many of the differences found were between scores of three and one.35,36 It has also been found that from the results of one study, failure to improve the FMS scores can be predicted by a low deep squat at initial collection of data.

To perform the deep squat test, the individual is instructed to stand with feet slightly wider than shoulder width apart so the instep of the foot is in line with the shoulders. Also, the subject's toes should be pointing straight ahead.4 The individual then holds a dowel overhead with a wide grip, body position looks like a Y. The dowel should stay overhead with the shoulders flexed and abducted and the elbows fully extended.4 Next, the individual is told to perform a slow, controlled squat until they reach below parallel with the floor.4

A score of three is given if the individual can perform the test and maintain alignment of the dowel overhead, knees aligned over feet, femur achieves below parallel to the ground, and upper torso is parallel with tibia. If the individual cannot properly perform the test, a 2x6 foot board is placed under his feet and the test is done again. A score of two
is given if the exercise is done successfully. A score of one is given if the individual cannot maintain balance and significantly deviates from the criteria to obtain a score of three. Zero is given to those individuals who experience pain.4

**Hurdle Step**

Next, the Hurdle Step test is done. It assesses functional mobility and stability at the hips, knees, and ankles.4 This test should be done on both the left and right side. Before the subject performs the test, tibial height must be measured at the tibial tuberosity using the dowel to obtain height measurement. The hurdle cord will then be adjusted to that height. To perform the hurdle step, first the individual stands facing the hurdle with feet together and aligned to touch the base of the hurdle.4 Further, the individual holds the dowel across the upper trapeziums.4 Next, the individual is asked to step over the hurdle in a controlled manner and touch the heel to the floor.4 After they complete a full touch of the heel to the floor, the individual returns to the starting position.4

A score of three is given if the exercise is completely successfully, while maintaining proper balance and the dowel and string remain parallel. Two is given if alignment is lost between ankles, knees, and hips, if the dowel and string do not stay even, and movement is observed in the lumbar spine. A one is given if there is a complete loss of balance or the individual hits the hurdle with his foot. Zero is again given if there is pain at any point during the activity.4

**In-Line Lunge**

The In-Line Lunge is performed to assess ankle, knee, hip, trunk, and shoulder mobility and stability.4,5 It should be done on both the right and left side. Prior to performing the in-line lunge, tibial length is measured from the floor to the tibial
tuberosity. The same measurement taken from the Hurdle Step test should be used for the In-Line Lunge test. The individual stands on the FMS board with the toe of one foot at the zero mark. The heel of the other foot is placed at the tibial height measurement. The dowel is placed behind the back, in-line with the spine. It should maintain contact with the head, thoracic spine, and sacrum throughout the entire movement. The hand opposite the front foot should hold the dowel behind the cervical spine, the other at the lumbar spine. Next, the individual is asked to lower himself into a lunge position, touch knee to the board just behind the front foot, and then return to starting position.

When scoring this test, the front leg is the leg being scored. A score of three is given if the individual maintains dowel contact with lumbar spine, thoracic spine, and head, no obvious trunk movement, and the knee touches the board. A score of two is given if dowel does not maintain contact, movement is observed in the trunk, and the individual is unable to contact the ground when in the lunge position. One is given if a complete loss of balance is observed thus not allowing the individual to complete the test. A zero is given for any pain experienced through-out the exercise.

Active Straight-Leg Raise

Cook included the Active- Straight Leg Raise to assess active hamstring and gastrocnemius range of motion while maintaining a fixed pelvis and not allowing the opposite leg to lift from the ground. This test should be done on both the left and right side. To perform this test the individual lies supine with head and arms flat on the floor and the FMS board perpendicular to the subject underneath the knees. Identification of the mid-point between the anterior superior iliac spine and the mid-point of the patella is made by the examiner and the dowel is placed at the mid-point. This is used to identify
which score is appropriate for the test. To receive a three, the individual should be
maintain a fully extended knee and flex the hip so the lateral malleolus moves past the
dowel.\textsuperscript{33} The opposite leg must stay in full contact with the ground, both feet remain
dorsiflexed and pointing towards the ceiling, and the individual's head should remain flat
on the floor.\textsuperscript{33} A score of two is given if the leg on the floor does not remain extended or
that leg rotates to assist the opposite leg in performing the test. To achieve a score of two,
the individual's lateral malleolus must be able to clear the dowel when it is placed between
mid-thigh and patella. A score of one is given if the individual is unable to clear the dowel
when it is place between mid-thigh and patella. Zero is given if there is pain.\textsuperscript{33}

\textbf{Shoulder Mobility}

The Shoulder Mobility test assesses bilateral shoulder adduction with internal
rotation and shoulder external rotation with abduction.\textsuperscript{5,33} The individual must also have
normal scapular mobility.\textsuperscript{5,33} This test should be done on both the left and right side. The
arm that is in shoulder abduction, flexion, and external rotation is that arm that should be
scored. Prior to performing the Shoulder Mobility test, hand length is measured (in inches)
using the dowel from the tip of the third finger to the most proximal wrist crease.\textsuperscript{33} When
performing the test, the individual should make his hands into a fist with thumbs inside the
fist. Next, the individual is asked to maximally adduct, extend, and internally rotate one
shoulder while maximally abducting, flexing, and externally rotating the other.\textsuperscript{33} The
position is held while the examiner measures the distance between the individual’s hands
at the closest point.

After completing the Shoulder Mobility test, the individual must perform a clearing
assessment to rule out impingement of the shoulder.\textsuperscript{33} This is done by placing the hand on
the opposite shoulder then flexing the shoulder by bringing the elbow towards the forehead.\textsuperscript{33} If the individual experiences pain during the clearing test, a score of zero is then given.\textsuperscript{33} A score of three is given when the fists are within one hand length apart; a two is given when the fists are within one and a half hand lengths; and a one is given if hands are farther than one and half hand lengths apart.\textsuperscript{33} Zero is given if there is pain.

After completing the Shoulder Mobility test, the individual must perform a clearing assessment to rule out impingement of the shoulder.\textsuperscript{33} This is done by placing the hand on the opposite shoulder then flexes the shoulder by bringing the elbow towards his forehead.\textsuperscript{33} If the individual experiences pain during the clearing test, a score of zero is then given.\textsuperscript{33} A score of three is given when the fists are within one hand length apart; a two is given when the fists are within one and a half hand lengths; and a one is given if hands are farther than one and half hand lengths apart.\textsuperscript{33}

**Trunk Stability Push-Up**

The Trunk Stability Push-up is the only test that is individualized for males versus females. The test assesses spinal stability in a neutral position while performing a closed-kinetic chain push-up.\textsuperscript{5,33} The individual lies on the floor in a prone position and then the hands are placed shoulder width apart at appropriate position. Women start with their thumbs aligned with the chin; men start with thumbs aligned at top of the forehead.\textsuperscript{33} The individual then performs one push-up ensuring the chest and stomach come off the floor at the same time, the knees stay fully extended, and ankles remain dorsiflexed.\textsuperscript{33} A score of three is given if the individual can complete the push-up correctly maintaining proper positioning. If the push-up cannot be performed with those hand positions, they are altered (men align with the chin; women align with the clavicle) and the push-up is performed
again.33 A score of two is given at this point if executed with no lag. A one is given if this position cannot be executed. This test requires a clearing assessment after. The clearing assessment is done by performing a spinal extension maintaining pelvic contact with the ground and having full elbow extension.33 If the individual experiences pain during the clearing test, a score of zero is then given.33

Rotary-Stability

The final test for the FMS is the Rotary-Stability test. This test requires neuromuscular control because the individual must flex the shoulder while extending the knee and hip on the ipsilateral side with minimal weight transfer to the stationary side.5,33 This test is the only test within the FMS that may assess multi-plane motions. This test should be done on both the left and right side.

The individual starts in a quadruped position with the board parallel to the spine on the floor. The shoulders and hips are flexed to 90 degrees and the ankles are dorsiflexed on the floor to perform this test.33 The individual’s thumbs, knees, and feet must contact the outside of the board. Next, the individual is instructed to extend the hip and flex the shoulder on the ipsilateral side only enough to clear the floor (approximately 6 inches).33 Then the individual flexes the hip and extends the shoulder on the same side so the elbow and knee touch, then resume the starting position.33 If this is done accurately, a score of three is given. If this cannot be done by the individual, he is instructed to perform the same motions but with opposite leg and arm.33 A score of two is given when this is appropriately completely. If the individual is unable to complete the exercise without losing balance or not touching knee to elbow, a score of one is given. Having the individual sit back towards their heels without pain completes the clearing test. Then the individual is instructed to
lower the chest and reach his hands in front of his body as far as possible. A score of zero is given if there is pain.33

Normative Values

When performing the FMS, the maximum score is a three for each test. Therefore, the maximum total score is 21.4,5 However, not many individuals are capable of obtaining a perfect score. Cook4,5 stated that the lower the score on the FMS, the greater the risk for injury. However, Cook has not provided a cut-off value for those at risk compared to those not at risk. Most researchers use the work done by Kiesel et al14 to distinguish the cut-off values for their particular studies. The purpose of their study was to compare the FMS scores of professional football players to the incidence of injury through-out the season.14 Kiesel et al.14 created a receiver-operator characteristic curve to determine the appropriate cut-off score using the FMS by finding the mean FMS score of all subjects (16.9) to those who sustained an injury throughout the competitive season (14.3). The results of his study showed that maximum specificity (0.91) and sensitivity (0.54) was seen at a score of 14 out of 21.14 This score of 14 has become the fundamental cut-off score used by many researchers.6,12,14,15,19,21-23,35,37-39 However, Schneiders et al.,15 stated that this cut-off value should be used with caution because the sample size was not diverse and suggests that future researchers have a more diverse athletic population. Schneiders et al.15 evaluated a more diverse population (108 females and 101 males) and found a mean composite score of 15.7 for all subjects with no significant difference between males (15.8) and females (15.6). While, this study did not look at injury rates, Schneiders et al.15, showed that the FMS can be used in mixed populations, which many studies have not demonstrated or evaluated. Another study used 622 healthy, middle-aged adults to provide normative data
and identify variables that could affect FMS scores. \(^4\) This study found the mean score for middle-aged men and women to be 14 (SD=2.8) and 14.5 (SD=2.8), respectively. \(^4\) Variables found to negatively affect FMS scores were age, body composition (BMI), and varying levels of physical activity. \(^4\) Other studies have also looked at injury rates and have indicated different cut-off values for the FMS. \(^6,9,15-17,21,22,25,32-35\) Some studies suggest the cut-off value should be higher, 15.7 \(^15\), 16.5 \(^16\) and 15.5 \(^17\) were found to have higher specificity and sensitivity.

One study tried to predict injury rates among Division I women’s basketball, soccer, and volleyball athletes using the FMS. \(^16\) Brown \(^16\) ran a receiver operator characteristic (ROC) curve analysis similar to the one conducted by Kiesel \(^14\) and performed an odd ratios. The study found the cut-off score with the highest sensitivity (0.615) and specificity (0.738) to be 16.5 out of 21. \(^16\) However, Brown \(^16\) acknowledged many differences between his study and that of Kiesel et al., \(^6\) one of which being level of play between Division I female athletes and professional male football players. Conversely, a study done by Cuson \(^17\) using the ROC curve analysis, found a total FMS score of 15.5 maximized sensitivity (0.50) and specificity (0.52). \(^17\) In this study, male and female Division I basketball players were evaluated to determine the ability of the FMS to identify acute lower extremity injury. \(^17\) Another study used a cut-off value of 16 for injury predictability in fire-fighters but provided no justification for this value. \(^24\)

In addition, to finding normative values used within the FMS, Kiesel et al. \(^14\) also compared professional football players’ FMS scores to the likelihood of injury during the competitive season. He concluded that those athletes who had not sustained an injury acquired a mean score of 17.4; however, those who had sustained an injury throughout the
season averaged a score of 14.3. The study performed by Kiesel et al., looked at predictability among professional football athletes, which is not very representative of a total athletic population, so Chorba et al. conducted a study that evaluated injury risk among female collegiate athletes. Chorba et al., found that of those who scored below a 14 on the FMS, 69% received an injury throughout the season. In addition, a cutoff score of 14 was used in a study on Marine Corp officer candidates. It was found that risk of injury was 2 times higher among those with FMS scores ≤14. Of those who scored ≤14, 45.8% ended up sustaining an injury. It was also seen that 30.6% of those who scored >14 also sustained an injury. The FMS’s ability to predict overuse injuries was inconclusive, had 12.5% of candidates with scores ≤14 sustained overuse injuries compared to 10.6% of those with scores >14. They found no significant differences in FMS scores when comparing injured to non-injured athletes throughout their perspective seasons. However, it was mentioned that after an odds ratio calculation was done using a cut-off of 16.5 out of 21, those who scored less than 16.5 were over 4 times more likely to be injured.

Appal et al. conducted a study testing a cutoff score of 14 for Division I male and female track and field athletes. There was no score difference between genders, but on average seniors (16.2±3.0) and juniors (16.2±2.8) scored higher than sophomores (14.7±3.0) and freshman (15.4±2.2). FMS scores were similar for injured and non-injured athletes. Results found that a FMS score of ≤14 was not a good predictor for track and field athletes. A more appropriate FMS score that maximized specificity and sensitivity could not be found, suggesting the FMS is not a strong injury predictor for athletes that mainly suffer from chronic and overuse injuries.
O’Connor et al.\textsuperscript{38} used a cutoff score of 14 to determine the FMS validity in 874 male Marine officer candidates. Candidates were separated into a 6-week short-cycle (SC) training group or a 10-week long-cycle (LC) training group. With a range of 6-21, the mean FMS score among all candidates was 16.6±1.7.\textsuperscript{38} After review of all FMS scores, researchers further separated data into score groups of ≤14, 15-17, and ≥18 score groups. The risk of injury was significantly higher in the ≤14 score group, but also higher in the ≥18 score group for the 10-week training group.\textsuperscript{38} When comparing injury and non-injury candidates, the scores for both were 16.7±1.7 with an odds ratio of 2.0 for sustaining a serious injury (95\% CI = 1.0-3.8).\textsuperscript{38} Sensitivity was 0.19 and specificity was 0.90.\textsuperscript{38} Although sensitivity was low, it was concluded that scores of ≤14 were associated with higher risk of injury but further research was warranted.\textsuperscript{38,39}

Although studies\textsuperscript{6,9,15-17,21,22,25,32-35} have been done to provide researchers with a cut-off FMS score, ranging from 14 to 17, more research needs to be conducted. To date, the research done by Kiesel et al.\textsuperscript{14} still appears to be the “gold standard” when determining a cut-off value for the FMS.

**Reliability**

Many studies involving the FMS have evaluated the intra-rater and inter-rater reliability.\textsuperscript{6-12} These studies, however, lack consistency in the methods. Some studies evaluate only novice raters and others compare experience among raters.\textsuperscript{7,8} Most researchers perform inter-rater and intra-rater reliability testing prior to the start of data collection to ensure satisfactory results.\textsuperscript{6-11,18}

**Inter-rater Reliability**
Sorenson\textsuperscript{18} completed an inter-rater reliability study and found that the median inter-rater reliability coefficient was acceptable (greater than 0.80) for all of the individual tests except for the rotary stability test (0.73).\textsuperscript{18} Three studies have looked solely at the use of novice raters when evaluating the FMS.\textsuperscript{7,8,12} Among novice raters, moderate to good reliability was reported (ICC\textsubscript{(3,1)},\textsuperscript{8(2,1)12}=0.74, 0.76).\textsuperscript{12} Other studies have tested reliability of the FMS using different levels of tester experience and knowledge. Good inter-rater reliability could be established at all levels of FMS expertise; however, those that have the most experience often times have the best reliability results.\textsuperscript{6,9,11}

One study established good inter-rater reliability using two experts (FMS certified for more than 10 years) and two novices (FMS certified for less than a year), with excellent agreement on 14 out of the 17 tests\textsuperscript{6}. Similar results were found (ICC\textsubscript{2,k}= 0.72) in another study but different examiner expertise levels were used.\textsuperscript{11} The researchers of this study used senior athletic training students, graduate athletic trainers, athletic trainers staffed at University of Toledo, and athletic trainers who had experience and were certified to score the FMS.\textsuperscript{11} Another expertise comparison study was completed among 1) a physical therapy student who had performed over 100 FMS tests, 2) an Athletic Training faculty member with a PhD in Biomechanics and Movement Science, who had no experience with the FMS, 3) a physical therapy student who had no experience using the FMS.\textsuperscript{9} Sufficient reliability between varying degrees of experience among the raters was found (ICC= 0.89).\textsuperscript{9}

Although researchers use different methods to perform reliability studies, it is meaningful that they all find moderate to good reliability results. More research should be done to confirm the reliability studies that have already been completed.

\textit{Intra-rater Reliability}
Intra-rater reliability studies have also been performed, which is very beneficial for future researchers and clinicians wishing to use the FMS. Generally the range of reliability has been seen from an ICC\(_{(3,1)}^{8}\)\(_{(2,1)}^{12}\) = 0.74- 0.91.\(^{8,9,12,18}\) Brigle\(^{11}\) found that those who have FMS experience and those who have the most clinical experience (regardless of FMS experience) have the best intra-rater reliability results (ICC\(_{2,k}\) = 0.91). Among other studies, Shultz, et al. \(^{10}\) found sufficient results in intra-rater reliability (Kalpha= 0.61) and stated that changes in the scoring is a result of the individual being tested, not the rater.

**Clinical Application**

The main purpose of the FMS is to help clinicians, strength and conditioning coaches, and other members associated with athletic performance in assessing the chance of injury for each individual athlete tested.\(^{4,5}\) Many clinicians have used the FMS in studies to predict injury rates among athletes.\(^{14,16,37}\) Further, some researchers have taken the predictive value results and then incorporated it into an intervention program for athletes at risk of injury.\(^{21-25}\) Due to the fact that Cook\(^{4}\) encouraged clinicians to use the FMS as a predictor tool, it is important that sufficient research is available to add credibility to his claim.

**Indicator of Athletic Performance**

It has been stated that FMS scores may also be an indicator of athletic performance.\(^{4,5}\) One study compared the relationship between the FMS and its ability to predict an individual’s athletic performance as it relates to the one repetition max (1RM).\(^{41}\) The researcher assessed strength, power, and velocity components of a movement and related them to the 1RM max and the FMS scores. The results of this study showed that FMS was not a good predictor of athletic performance and that one rep max had a better
relationship to athletic performance.41 One rep max was significantly correlated to all the dependent variables tested (club head swing velocity: $r= 0.805$; vertical jump: $r= 0.869$; 10m sprint: $r= -0.812$; 20m sprint: $r= -0.872$; and t-test completion time $r= -0.758$).41 On the other hand, FMS had no significant correlation between any of the performance variables.41 This information is viable for those looking to do more research on the FMS as a predictor of athletic performance because it does not show results in favor of the FMS, according to this one study.

**Intervention Programs**

Some researchers have taken the knowledge that a lower score indicates a higher chance of injury and then implemented an intervention program to correct the deficiencies.21-25,42 The goal of these studies is to see if an intervention program focusing on the deficiencies will increase an individual’s score on the FMS and lower the risk of injury.21-25,42 A study performed using military soldiers as the subjects, implemented a functional training program that was designed to better their FMS scores and allow return to active duty at a faster rate.22 The results of this study showed that implementation of a functional training program proved to be beneficial in raising the soldiers’ FMS scores (mean improvement = 2.5 points).22 It was noted that most improvements were found in the deep squat, active straight-leg raise, and shoulder mobility.22 Another intervention study was done to evaluate if an off-season intervention program would improve scores of football players.21 The results showed an improvement in FMS scores following the intervention (mean for linemen: pre- 11.8; post- 14.8 and mean for non-linemen: pre- 13.3; post- 16.3).21 It must be noted that there was no control group for either study.21,22
One study examined the application of Kinesio Tape (KT) as a means of improving lower extremity FMS scores.42 Sixteen Division II female varsity basketball players were tested, as well as 16 non-varsity female students.42 All participants were first assessed performing the lower extremity FMS tests; the Deep Squat, Hurdle-step, and Inline Lunge. Scoring was modified to be more descriptive. Participants were randomly assigned into either the treatment or control group (n=16 each) 42 A second investigator applied KT (with 20-25% stretch and pressure downward to insertion) to the treatment group, immediately before the second test, along the Sartorius (hip flexion), Rectus Femoris (knee extension), Hamstrings (knee flexion), Patella, Tibialis Anterior (dorsiflexion), and Peroneus (plantar flexion).42 All 32 participants were reassessed 2-4 days after the initial assessment. Results revealed a significant interaction for the Hurdle Step only, this may have been because it is a non-weight-bearing test. There were no differences in the Deep Squat and In-Line Lunge tests.42

Core Stability as it relates to the FMS

Core stability as it relates to the FMS has been evaluated in two studies.24,25 This is an important factor to consider because many individuals fail to execute functional activities because of insufficient core strength and endurance.4,24,25,33 One researcher attempted to establish a relationship between functional movement, core stability, and performance.25 The researchers used a standard regression analysis to determine whether the FMS and core stability together could predict injury and performance success.25 Core stability was measured using McGill’s trunk muscle endurance tests (trunk flexor, back extensor, and right and left lateral trunk musculature).25 The results showed that neither the FMS nor core stability could assist in predicting an individual's abilities when
undergoing the performance tests used in this study. However, the author mentions that the results seem odd because of the acknowledged importance of the core during the performance of the FMS tests. The study done by Peate et al. used firefighters as subjects and assessed FMS scores and a core stabilization intervention program to lower the risk of injury due to the awkward positions they are placed in as a part of their job. Time lost from full duty activity decreased by 62% after an intervention program was completed. Also, total injury rates decreased to 44% with an implementation of an intervention program. More research needs to be done to show relationship between the FMS and core stabilization among injury rates in active individuals.

**Alternative Approach**

One study found in the literature took a different approach to scoring and analyzing the FMS. Frost et al. used firefighters and scored each individual on how they chose to perform each of the seven tests rather than how well they performed the tests. The protocol for the FMS instructs the evaluator to score based on how well the test is performed (i.e. no discrepancies in balance, muscle activation, and joint motion). Frost et al. however, chose not to give full descriptions of how to complete each exercise, rather evaluated movement patterns through each exercise. There were two intervention groups and one control group. The average FMS scores did not change among any group or with use of any method following a 12 week training protocol. However, there was change found pre- to post-intervention programs among the control group. One flaw in the study could be that the researchers decided to test how (i.e. technique) an individual performed the test, rather than using the standard protocol prescribed by Cook.
Another study looked to investigate improving the precision of the FMS by implementing a 100-point scoring system.\textsuperscript{43} The goal was to improve predictive values of the FMS by providing more information to be evaluated through itemized scoring. Thirty middle-school age subjects were recorded performing the FMS and assessed by FMS certified raters.\textsuperscript{43} Examiners were able to view the tape as many times as possible. The 100-point scale scores the movement quality from 1 (unable to produce movement) to a maximum score, which differed for each test (indicating no compensatory movement to complete the pattern). \textsuperscript{43} Each of the seven FMS movements were given weighted values (totaling 100 points) and each were considered as a lower-level or higher-level task. The inline lunge (20) was weighted highest, followed by the deep squat (18), hurdle step (18), trunk stability push up (12), rotary stability (12), active straight-leg raise (10), and then the shoulder mobility (8) test.\textsuperscript{43} The 100 point scale ICC was 0.99 for the overall score on the FMS.\textsuperscript{43} The researchers acknowledged the reliance of video-based assessment as a downfall of the 100-point scale and reliability may be inflated as a result. Suggested studies were to look at real-time examinations (without assessing by video) of experienced FMS raters to see if the 100-point scale could be performed with efficiency.

**Compared to Other Pre-participation Screening Tools**

Some researchers have made an effort to compose a different pre-participation screening tool that relates to the FMS.\textsuperscript{28} The researchers have done five to ten years of testing using many different, unspecified battery tests, modifying them, and resulting with nine tests.\textsuperscript{28} Frohm et al.\textsuperscript{28} used modified versions of the deep squat, in-line lunge, straight-leg raise, push-up, shoulder mobility, and the rotary stability, plus one test from the United States Tennis Association (single-leg squat) and two tests from within the research group.
(double-leg straight-leg raise and seated rotation) to configure a nine-test screening tool. The researchers decided to test each subject without shoes, which does not seem to represent an athletic environment in which shoes are always worn. Reliability of this testing protocol is good (ICC= 0.80). However, it does add three additional tests and time for the clinician compared to the FMS, which is something a clinician may consider when choosing a predictive battery-tool such as this one and the FMS.

The study by O'Connor et al. recorded physical fitness testing scores out of 300 points. Points were given based on performance doing pull-ups to exhaustion, two minute abdominal crunches, and a three mile run. Those candidates with scores <280 were found to be 2.2 times likely to have a FMS ≤14 and significantly more likely to incur injury. Further, physical fitness scores were found to be just as predictive of future injury as FMS scores, and had a higher sensitivity.

An article by Kritz, et al. discussed the importance of static posture assessment protocols over that of functional movement protocols, such as the FMS. The authors asked the question of whether standing static posture will be predictive about how an athlete will move while performing his specific sport. Based on the literature to date, no conclusions can be made as to whether a specific static posture will benefit athletic performance. However, no research was found to say a certain static posture would hinder the athlete. This is of interest because static discrepancies may be beneficial to the sport in which that athlete is involved and this should be addressed before dynamic discrepancies are identified and interpreted.
Further, no research has been found on the validity of the FMS, which may be beneficial to clinicians hoping to use the tool. Also, it would allow better comparison between FMS and other functional screening tools.
References

17. Cuson MJ. *FMS scores as a predictor of acute lower extremity division I intercollegiate basketball players*. Toledo: Exercise Science, University of Toledo; 2010.


20. White SMM. *The ability of the Functional Movement Screen to predict musculoskeletal injuries in a cohort of New Zealand military personnel*: Physiotherapy, University of Otago; 2013.


Procedures Protocol

Before the Subject Arrives
1. Set-up FMS equipment (2x6 board, dowel, hurdle supplies)
2. Have pencil and clipboard with
   a. Grading form
   b. Protocol for each test

When Subject Arrives
1. Ensure the subject is properly clothed (athletic shoes, athletic shorts, and fitted top)
2. Have subject read and sign informed consent
   A. Ensure the subject has met the inclusion criteria.
   B. Determine if the subject meets any of the exclusion criteria
   C. Get age, height, and weight
3. Have the subject fill out the health history questionnaire on Google Docs.
4. Ask if the subject has any questions prior to initiation of the tests
5. Measure tibial height by measuring from the floor to the top center of the tibial tuberosity (can use hurdle height too)
6. Begin testing protocol (read word for word to the subject)—Make sure you say the FULL instructions before the test is completed!

a. Deep Squat:
   Equipment: Dowel, 2x6 board
   i. Stand tall with your feet approximately shoulder width apart and toes pointing forward
   ii. Grasp the dowel in both hands and place it horizontally on top of your head so your shoulders and elbows are at 90 degrees
   iii. Press the dowel so that it is directly above your head
   iv. While maintaining an upright torso, and keeping your heels and the dowel in position, descend as deep as possible
   v. Hold the descended position for a count of one, then return to the starting position
   vi. Do you understand the instructions?
   *SCORE the movement
   *Allow three attempts at the movement
   *If a score of three is not achieved, repeat above instructions using the 2 x 6 under the client’s heels

b. Hurdle Step: TIBIAL HEIGHT! *Score the hurdle step leg*
   Equipment: Dowel, Hurdle
   i. Stand tall with your feet together and toes touching the test kit
   ii. Grasp the dowel with both hands and place it behind your neck and across the shoulders
   iii. While maintaining an upright posture, raise the right leg and step over the hurdle, making sure to raise the foot towards the shin and maintaining foot alignment with the ankle, knee, and hip
iv. Touch the floor with the heel and return to the starting position while maintaining foot alignment with the ankle, knee, and hip

v. Do you understand the instructions?
*Score the moving leg
*Repeat the test on the other side
*Allow three attempts at the movement

c. In-Line Lunge: *score the front leg*

Equipment: Dowel, 2x6 Board

i. Step onto the 2x6 with a flat right foot and your toe on the zero mark
ii. The left heel should be placed at (The tibial measurement) mark
iii. Both toes must be pointing forward, with feet flat
iv. Place the dowel along the spine so it touches the back of your head, your upper back and the top of your sacrum
v. While grasping the dowel, your right hand should be against the back of your neck, and the left hand should be against your lower back
vi. Maintaining an upright posture so the dowel stays in contact with your head, upper back and top of the buttocks, descend into a lunge position so the right knee touches the 2x6 behind your left heel.

vii. Return to the starting position
viii. Do you understand these instructions?

*Score the movement
*Repeat the test on the other side
*Allow three attempts at the movement

d. Shoulder Mobility: *measure the top shoulder*

Equipment: Measuring tape

*Prior to completion of the test, measure hand length by measuring the distance from the distal wrist crease to the tip of the longest digit
i. Stand tall with your feet together
ii. Make a fist so your fingers are around your thumbs
iii. In one motion, place the right fist over head and down your back as far as possible while simultaneously taking your left fist up your back as far as possible
iv. Do not “creep” your hands closer after their initial placement
v. Do you understand these instructions?

*Measure the distance between the two closest points of each fist
*Score the movement
*Repeat the test on the other side

CLEARING TEST:

i. Stand tall with your feet together and arms hanging comfortably
ii. Place your right palm on the front of your left shoulder
iii. While maintaining palm placement, raise your right elbow as high as possible
iv. Do you feel pain? If pain, a score of zero is given

*Repeat the test on the other side
e. Active Straight-Leg Raise:

   **Equipment:** Dowel, measuring tape, 2x6 board

   * **Tester instructions:** find the position between the ASIS and the joint line of the knee and place the dowel at that position, perpendicular to the ground. If the malleolus passes the dowel, give a 3. If it does not, move the dowel between the knee joint and hip joint.

   i. Lay flat on your back with the back of your knees touching the floor and your toes pointing up
   ii. Place both arms next to your body with the palms facing up
   iii. With the right leg remaining straight and the back of your left knee maintaining contact with the floor, raise your right foot as high as possible
   iv. Do you understand these instructions?

   *Score the movement
   *Repeat the test on the other side

f. Trunk Stability Push-up

   i. Lie face down on your stomach with your arms extended overhead and your hands shoulder width apart
   ii. Pull your thumbs down in line with the _____ (forehead for men, chin for women)
   iii. With your legs together, pull your toes toward the shins (dorsiflex), maximally extend your knees, and raise your elbows off the ground
   iv. While maintaining a rigid torso, push your body as one unit into a pushup position
   v. Do you understand these instructions?

   *Score the movement
   * Allow three attempts at the movement
   *Repeat the instructions with appropriate hand placement, if necessary

   **Tester instructions:** If the subject is unable to perform the action, men should move their hands to align with the chin and women should move their hands to align at shoulder level

   **CLEARING TEST:**

   i. While lying on your stomach, place your hands, palms down, under your shoulders
   ii. With no lower body movement, press your chest off the surface as much as possible by straightening your elbows
   iii. Do your understand these instructions?
   iv. Do you feel any pain? If pain, a score of zero is given

   g. Rotary Stability *measure the upper limb* (need a soft surface)

   **Equipment:** 2x6 Board

   i. Get on your hands and knees over the 2x6 board so your hands are under your shoulders and your knees are under your hips
   ii. The thumbs, knees, and toes must contact the sides of the 2x6 board, and the toes must be pulled toward the shins
iii. At the same time, reach your right hand forward and right leg backward, like you are flying
iv. Then without touching down, touch your right elbow to your right knee directly over the 2x6
v. Return to the extended position
vi. Return to the start position
vii. Do you understand these instructions?
*Score the movement
*Repeat the test on the other side

**Tester instructions:** if a score of three is not attained, have the person perform a diagonal pattern using the opposite shoulder and hip in the same manner. During this diagonal variation, the arm and leg need not be aligned over the board; however, the elbow & knee DO need to touch over it.
*If necessary, instruct the client to use a diagonal pattern of right arm and left leg
*Repeat the diagonal pattern with left arm and right leg
*Score the movement

**CLEARING TEST:**
i. Get on all fours, rock your hips toward your heels
ii. Lower your chest to your knees, and reach your hands in front of your body as far as possible. (prayer position)
iii. Do you understand these instructions?
iv. Do you feel pain? If pain, a score of zero is given
## Underlying Theoretical Components of the Functional Movement Screen Scoring Sheet

<table>
<thead>
<tr>
<th>TEST</th>
<th>RAW SCORE</th>
<th>FINAL SCORE</th>
<th>COMMENTS</th>
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<tbody>
<tr>
<td>Deep Squat</td>
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<td>Hurdle Step</td>
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<td>Inline Lunge</td>
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<td>Impingement Clearing Test</td>
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<td>Trunk Stability Push-up</td>
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<td>Press-up Clearing test</td>
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<td>66</td>
</tr>
</tbody>
</table>
Health History Questionnaire

The Functional Movement Screen

Please fill this form out to the best of your ability. All information will be kept confidential. If a question doesn’t apply please avoid leaving blank and put "no" or "n/a" for your answer.

Research Study I.D. #
Will be assigned by your examiner

Please provide your first and last names.

How old are you?

What is your gender?
☐ Male
☐ Female

Is there a chance you are/could be pregnant?
☐ I am a male
☐ Yes
☐ No

What grade are you in?
☐ Freshman
☐ Sophomore
☐ Junior
☐ Senior
☐ 5th year Senior
☐ 1st year Grad
☐ 2nd year Grad
☐ Other: ____________________________

Are you left or right limb dominant?
☐ Right
☐ Left
☐ R handed, L footed
☐ L handed, R footed
Are you currently suffering from any illness (i.e. common cold, ear infection, sinus infection)?
Please indicate your current condition if you have one.

Have you suffered from any injury within the past six months that caused you to miss more than a day of exercise or training? (i.e. joint sprains, muscle strains, fractures) When did it happen?
If so, please explain.

Have you ever had any major surgeries? (Excluding dental) If so, approximately how long ago?

Are you currently undergoing any rehabilitation for a current or past injury?
If so, please explain.

Have you ever done the Functional Movement Screen before?
☐ Yes
☐ No
Are you a member of any of the following?
- ROTC
- IU Cheer
- Modern Dance
- Novice Rowing
- None of the above

Are you on the roster of Indiana University varsity or club sport team?
- No
- Varsity
- Club

If you answered varsity or club to the previous question, please name what team(s)/sport(s):

What (additional) sports or physical activities (weight lifting, intramurals, running, etc.) do you participate in on your own?

On average, how many physical activity/training sessions/practices do you participate in per week?

On average, how long would you say each physical activity/training session/practice session lasts?
(in minutes or hours)
When participating in physical activity, how would you rate the intensity of the majority of your training session

- [ ] minimal intensity
- [ ] light intensity
- [ ] moderate intensity
- [ ] high intensity
- [ ] rigorous intensity

Please provide your email if it's ok to contact you in the future for further questions regarding your Functional Movement Screen results.
Leave blank if you'd prefer not to.

Submit
Inter-Rater Reliability

<table>
<thead>
<tr>
<th>FMS test</th>
<th>Pearson-R Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deep Squat</td>
<td>1.00</td>
</tr>
<tr>
<td>Hurdle Step</td>
<td>0.77</td>
</tr>
<tr>
<td>In-Line Lunge</td>
<td>0.84</td>
</tr>
<tr>
<td>Shoulder Mobility</td>
<td>1.00</td>
</tr>
<tr>
<td>Active SLR</td>
<td>1.00</td>
</tr>
<tr>
<td>Trunk Stability Push-up</td>
<td>0.92</td>
</tr>
<tr>
<td>Rotary Stability</td>
<td>0.95</td>
</tr>
<tr>
<td>Overall Score</td>
<td>0.82</td>
</tr>
</tbody>
</table>
Intra-Rater Reliability

Deep Squat Score

<table>
<thead>
<tr>
<th>Reliability Statistics</th>
<th>Cronbach's Alpha</th>
<th>N of Items</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>.923</td>
<td>2</td>
</tr>
</tbody>
</table>

**Intraclass Correlation Coefficient**

<table>
<thead>
<tr>
<th></th>
<th>Intraclass Correlation</th>
<th>95% Confidence Interval</th>
<th>F Test with True Value 0</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>.857</td>
<td>.610 - .956</td>
<td>13.000 - 11.120</td>
</tr>
<tr>
<td>Single Measures</td>
<td>.923</td>
<td>.757 - .976</td>
<td>13.000 - 12.000</td>
</tr>
<tr>
<td>Average Measures</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Two-way random effects model where both people effects and measures effects are random.

a. Type A intraclass correlation coefficients using an absolute agreement definition.

b. The estimator is the same, whether the interaction effect is present or not.

**ICC(2,k) Deep Squat** = **0.857**

Standard Error of Measurement (SEM) = 0.21

n=12, largest standard deviation= 0.52

Hurdle Step Score

<table>
<thead>
<tr>
<th>Reliability Statistics</th>
<th>Cronbach's Alpha</th>
<th>N of Items</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>.807</td>
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</table>

**Intraclass Correlation Coefficient**

<table>
<thead>
<tr>
<th></th>
<th>Intraclass Correlation</th>
<th>95% Confidence Interval</th>
<th>F Test with True Value 0</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>.857</td>
<td>.221 - .879</td>
<td>5.162 - 12.000</td>
</tr>
<tr>
<td>Single Measures</td>
<td>.793</td>
<td>.362 - .936</td>
<td>5.162 - 12.000</td>
</tr>
<tr>
<td>Average Measures</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Two-way random effects model where both people effects and measures effects are random.

a. Type A intraclass correlation coefficients using an absolute agreement definition.

b. The estimator is the same, whether the interaction effect is present or not.

**ICC(2,k) Hurdle Step** = **0.657**

Standard Error of Measurement (SEM) = 0.29
n=12, largest standard deviation= 0.49

**Inline Lunge Score**

<table>
<thead>
<tr>
<th>Cronbach's Alpha</th>
<th>N of Items</th>
</tr>
</thead>
<tbody>
<tr>
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<table>
<thead>
<tr>
<th>Intraclass Correlation</th>
<th>95% Confidence Interval</th>
<th>F Test with True Value 0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single Measures</td>
<td>1.000</td>
<td>.</td>
</tr>
<tr>
<td>Average Measures</td>
<td>1.000</td>
<td>.</td>
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</tbody>
</table>

Two-way random effects model where both people effects and measures effects are random.

a. Type A intraclass correlation coefficients using an absolute agreement definition.
b. The estimator is the same, whether the interaction effect is present or not.

ICC(2,k) Inline Lunge = **0.999**
Standard Error of Measurement (SEM)= 0.01
n=12, largest standard deviation= 0.51

**Shoulder Mobility Score**

<table>
<thead>
<tr>
<th>Cronbach's Alpha</th>
<th>N of Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>.972</td>
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<table>
<thead>
<tr>
<th>Intraclass Correlation</th>
<th>95% Confidence Interval</th>
<th>F Test with True Value 0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single Measures</td>
<td>.946</td>
<td>.839</td>
</tr>
<tr>
<td>Average Measures</td>
<td>.972</td>
<td>.912</td>
</tr>
</tbody>
</table>

Two-way random effects model where both people effects and measures effects are random.

a. Type A intraclass correlation coefficients using an absolute agreement definition.
b. The estimator is the same, whether the interaction effect is present or not.

ICC(2,k) Shoulder Mobility = **0.946**
Standard Error of Measurement (SEM)= 0.20
n=12, largest standard deviation= 0.85
**Active Straight Leg Raise Score**

<table>
<thead>
<tr>
<th>Reliability Statistics</th>
<th>Cronbach's Alpha</th>
<th>N of Items</th>
</tr>
</thead>
<tbody>
<tr>
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<td>.901</td>
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<table>
<thead>
<tr>
<th>Intraclass Correlation Coefficient</th>
<th>95% Confidence Interval</th>
<th>F Test with True Value 0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single Measures</td>
<td>.701</td>
<td>.436</td>
</tr>
<tr>
<td>Average Measures</td>
<td>.883</td>
<td>.607</td>
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</table>

Two-way random effects model where both people effects and measures effects are random.

- a. Type A intraclass correlation coefficients using an absolute agreement definition.
- b. The estimator is the same, whether the interaction effect is present or not.

**Trunk Stability Push Up Score**

<table>
<thead>
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</tr>
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<tbody>
<tr>
<td></td>
<td>.977</td>
<td>2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Intraclass Correlation Coefficient</th>
<th>95% Confidence Interval</th>
<th>F Test with True Value 0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single Measures</td>
<td>.956</td>
<td>.867</td>
</tr>
<tr>
<td>Average Measures</td>
<td>.977</td>
<td>.929</td>
</tr>
</tbody>
</table>

Two-way random effects model where both people effects and measures effects are random.

- a. Type A intraclass correlation coefficients using an absolute agreement definition.
- b. The estimator is the same, whether the interaction effect is present or not.

**ICC(2,k) Active Straight Leg Raise** = **0.791**

Standard Error of Measurement (SEM) = 0.31

n=12, largest standard deviation= 0.69

**ICC(2,k) Trunk Stability Push Up** = **0.956**
Standard Error of Measurement (SEM) = 0.20  
n=12, largest standard deviation = 0.95

**Rotary Stability Score**

<table>
<thead>
<tr>
<th>Reliability Statistics</th>
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<tbody>
<tr>
<td></td>
<td>1.000</td>
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<table>
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<tbody>
<tr>
<td></td>
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<td>Value</td>
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<tr>
<td>Single Measures</td>
<td>1.000</td>
<td></td>
</tr>
<tr>
<td>Average Measures</td>
<td>1.000</td>
<td></td>
</tr>
</tbody>
</table>

Two-way random effects model where both people effects and measures effects are random.

a. Type A intraclass correlation coefficients using an absolute agreement definition.

b. The estimator is the same, whether the interaction effect is present or not.

ICC(2,k) Rotary Stability = 0.999

Standard Error of Measurement (SEM) = 0.01  
n=12, largest standard deviation = 0.28

**Total Score**

<table>
<thead>
<tr>
<th>Reliability Statistics</th>
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<tbody>
<tr>
<td></td>
<td>.908</td>
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<table>
<thead>
<tr>
<th>Intraclass Correlation Coefficient</th>
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<th>F Test with True Value 0</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Value</td>
</tr>
<tr>
<td>Single Measures</td>
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<td>10.857</td>
</tr>
<tr>
<td>Average Measures</td>
<td>.902</td>
<td>10.857</td>
</tr>
</tbody>
</table>

Two-way random effects model where both people effects and measures effects are random.

a. Type A intraclass correlation coefficients using an absolute agreement definition.

b. The estimator is the same, whether the interaction effect is present or not.

ICC(2,k) Total Score = 0.821

Standard Error of Measurement (SEM) = 0.51  
n=12, largest standard deviation = 1.2