Reliability of the Functional Movement Screen Using a 100-point Grading Scale: 1765

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Interrater Reliability of Videotaped Performance on the Functional Movement Screen Using the 100-Point Scoring Scale

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ABSTRACT

The purpose of this article was to determine the interrater reliability of the 100-point Functional Movement Screen (FMS) scoring scale. Thirty middle school-age students participated in this study. Each participant was videotaped performing the 7 movements of the FMS and scores were obtained. The videos were then analyzed by 2 separate raters using the new 100-point scoring system. Interrater reliability was calculated for each movement and the composite score using the intraclass correlation coefficients model. Interrater reliability for the individual components of the 100-point FMS scale ranged between 0.91 and 1.00. Composite interrater reliability was 0.99. The left lunge component of the FMS scale had the lowest interrater reliability at 0.91, whereas the shoulder mobility, active straight-leg raise, and trunk stability push up had perfect reliability at 1.00. Results of this study suggest the proposed 100-point FMS scale can be scored with a high level of interrater reliability in trained raters.

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An estimated 7 million Americans seek medical attention annually for sport-related injuries. This translates into 25.9 episodes per 1000 individuals in the population.[1,2] It has been estimated that 48% to 76% of these episodes are associated with a mechanism of overuse.[3,4] Furthermore, the most consistent risk factor identified in prospective studies in athletics is previous injury.[5-11] Because previous injury is a potential risk factor for future injury, it may be that some physiological characteristic may be altered after the initial injury.[12-16] The changes in physiologic function that occur following an injury are frequently distant from the original site of injury and are likely not observable with a single traditional measure of impairment.[12-16]

In an attempt to capture the complex construct of motor control, movement-oriented tests that assess multiple domains of movement have been developed.[17-19] Tasks requiring coordinated total body movements that are visually observed and scored in an objective manner may, in part, help us understand which global motor control changes occur following injury. Recently, researchers have used comprehensive movement screening to identify athletes at an increased risk of injury.[17-22] It has been suggested that comprehensive screening of movement patterns may provide a more robust model for injury risk detection.[12,17,18]

The Functional Movement Screen (FMS) has been shown to be a reliable and valid test to rate quality of total body movement patterns.[18-21] The FMS is a field expedient screen that comprises 7 tests (deep squat, hurdle step, trunk stability push up, active straight-leg raise, shoulder mobility, rotary stability, and inline lunge), which have traditionally been scored on an ordinal scale from 0 to 3.[19] The overall score (sum of the scores on each subtest) of the FMS has successfully identified individuals with an elevated risk for injury among professional football players, firefighters, and military officers.[18,20,21] In addition, professional football players who engaged in an individualized training program evidenced improved FMS scores, suggesting that the FMS score may be a modifiable risk factor.[22] Although the overall score has been a successful predictor in terms of injury, it may be beneficial to incorporate more precision in the FMS scoring criteria to capture a greater amount of information from the screen. One of the limiting factors of the FMS is that it serves only as a filter to detect large limitations of fundamental movement. Increasing the precision of the FMS, namely by itemizing the scoring of each subtest, may result in greater sensitivity of the screen in responding to intervention and detecting injury risk.

In response to a desire for increased precision of the 21-point FMS scoring system, the 100-point FMS scoring system was developed. The goal of the 100-point FMS was to provide practitioners and researchers with additional information to improve the predictive value of the FMS. This was achieved by improving measurement precision, which may potentially lead to targeted intervention techniques to improve functional movement. For example, as opposed to stating that the client received a score of 1 on the deep squat test (as scored by the 21-point FMS scoring system), a clinician could now record a 6 on the 100-point scale. This score would suggest that although the client was able to have his or her hips drop below parallel when using the board, one of the additional criteria (ie, tibia/torso parallel, dowel behind toes, or knees aligned over toes) was not met during the performance. As a result, the reason the client did not receive a score of 18 can now be identified with increased precision. Furthermore, itemized scoring of the subtests may be helpful in targeting an intervention strategy toward clearing the weakest link of the weakest movement, as opposed to focusing on the entire movement strategy. The use of this system may improve the predictive value of the FMS by improving the measurement precision; however, the reliability of the 100-point scoring system has not been established.

The FMS has been established as being a meaningful tool in identifying individuals at an elevated risk for injury. However, there is a need for incorporating additional precision in the score to potentially improve the FMS injury prediction ability and intervention specificity. Therefore, the purpose of the current study was to assess the reliability of a new scoring method that weighs the criterion for all of the components utilized in scoring each of the FMS tests. It was hypothesized that the new 100-point scoring criteria would provide high levels of intertester reliability using video-based analysis by raters who were trained in the new scoring criteria.

METHODS

Participants

Thirty middle school-age students were recruited to participate in the study. All participants of the reliability study were part of a larger study assessing the effects of a movement retraining program on functional movement scores. All children were free from musculoskeletal injury and were actively participating in physical education class at the time of data collection. The study was approved by the institutional review board at the investigators' university. Informed assent and consent were received by the participant and each participant's guardian or parent.

Overview of the Functional Movement Screen

Performance on the FMS was examined in all study participants. The FMS examines movement quality during a series of 7 standardized fundamental movement patterns (Figure). The movements included in the FMS are the deep squat, trunk stability push up, inline lunge, shoulder mobility, hurdle step, active straight-leg raise, and rotary stability.[19] All tests, with the exception of the trunk stability push up and deep squat, were scored for both the left and right sides. The 100-point FMS scores the quality of movement on a continuum from 1 (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). In the 100-point scoring system, performance on each test for each limb, when appropriate, is summated to provide a score for each individual test along with a score from all of the bilaterally graded tests.

Testing Protocol

Due to time constraints within the school day, data collection occurred over 2 days. The FMS typically takes a trained individual less than 15 minutes to administer. For all of the subtests, the participant was provided a

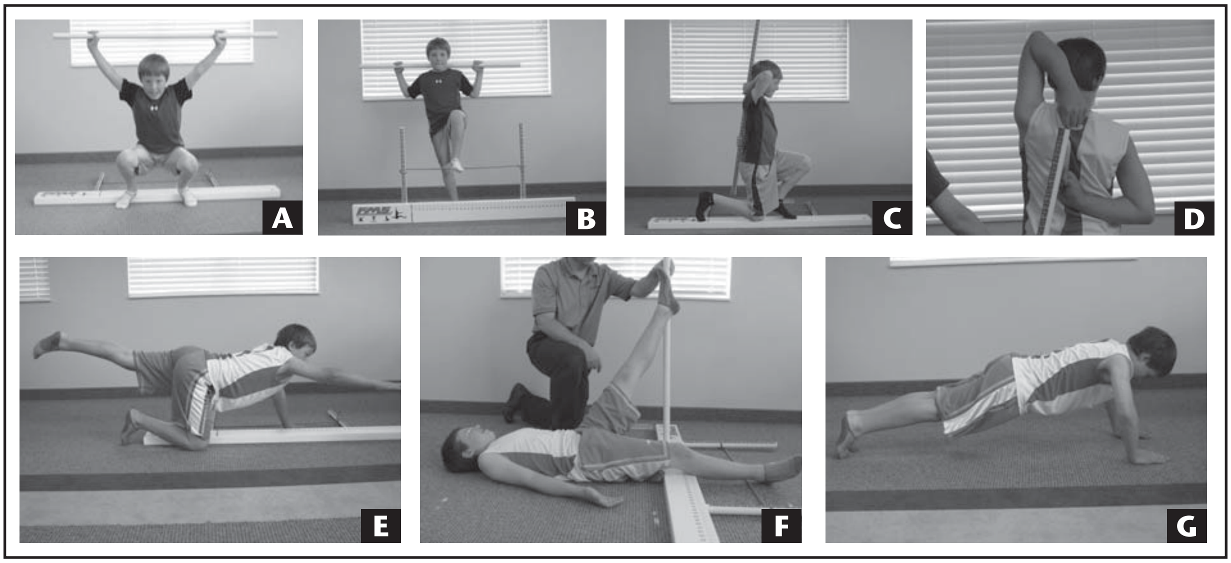

Figure. Examples of different functional movement screen tests: (A) deep squat, (B) hurdle step, (C) inline lunge, (D) shoulder mobility, (E) rotary stability, (F) active straight-leg raise, and (G) trunk stability push up.

standard set of directions and then performed 3 trials of each test. Video cameras were placed perpendicular to the sagittal plane to record movements during the squat, hurdle step, inline lunge, rotary stability, active straight-leg raise, and trunk stability push up. Video cameras (Samsung SC-D363; Samsung Electronics, Seoul, Korea) were also placed perpendicular to the frontal plane to record movements during the testing for the inline lunge, hurdle step, and deep squat. The video cameras were placed at a distance such that the tallest child could be captured performing the overhead press at the beginning of the squat. Camera positions were maintained for the entire collection. All data from the video cameras were recorded directly to Mini HD video cassette tapes (Maxell DVP-126EXL; Hitachi-Maxell, Ltd, Osaka, Japan). The data were then copied onto a computer hard drive for the scoring of the performances.

Scoring of the Functional Movement Screen Videos

Videotaped performance on the FMS was scored by 2 individuals who were trained and certified in the 21-point FMS scoring system and had been oriented to the 100-point scoring system. No additional training was required other than an orientation to the weighting criteria of the scoring because the 100-point scale simply assigns numeric values to the existing 21-point scoring criteria (Table 1). Weighting of the tests and the test items was determined based on the expert opinion of the authors of the current article. One author (K.B.K.) was one of the original developers of the 21-point scale. Each practitioner scored each of the video performances of all participants. The practitioners were able to view the tape as many times as needed to adequately score the performance. The raters typically viewed the performances between 1 and 2 times each, and on average the total time for the videotape scoring took less than 10 minutes. The practitioners were blinded to each other's scores during the process and provided their scores directly to the research team for analysis.

100-Point Functional Movement Screen Rationale

The FMS has an inherent neurodevelopment hierarchy in the tests. This hierarchy was the foundation for providing a weighting system to each of the tests. In developing the weighting system for the 100-point scoring, it was determined that lower-level tasks would not be weighted as high as higher-level tasks. The joint mobility assessment tests were assigned a weighting of 8 points for shoulder mobility and 10 points for the active straight-leg raise. The next level of tests, based on the neurodevelopmental progression, are considered to be the core stability tests. Both of these tests, the trunk stability push up and rotary stability, were assigned a maximum score of 12. Finally, the top tier tests of the FMS are the deep squat, hurdle step, and inline lunge. Because the inline lunge requires eccentric control of lower extremity flexion in a narrow base of support, this pattern was weighted slightly higher (20) than the deep squat (18) and the hurdle step (18). All

TABLE 1

Scoring Sheet for the 100-Point Functional Movement Screen Scoring System[a]

MOVEMENT	SCORE
Deep squat[b] (18 points possible)	
Upper torso is parallel with tibia or toward vertical	6
Knees are aligned over feet	8
Dowel aligned over feet	4
With board[c]	
Femur below horizontal	2
Upper torso is parallel with tibia or toward vertical	2
Knees are aligned over feet	2
Dowel aligned over feet	2
Hurdle step[d] (18 points possible)	
Right	
Foot clears cord (does not touch)	5
Hips, knees, and ankles remain aligned in the sagittal plane	2
Minimal to no movement is noted in lumbar spine	1
Dowel and hurdle remain parallel	1
Left	
Foot clears cord (does not touch)	5
Hips, knees, and ankles remain aligned in the sagittal plane	2
Minimal to no movement is noted in lumbar spine	1
Dowel and hurdle remain parallel	1
Lunge[e] (20 points possible)	
Right	
Knee touches behind heel	2
Dowel and feet remain in sagittal plane	2
Dowel contacts maintained	2
Dowel remains vertical	2
No torso movement noted	2
Left	
Knee touches behind heel	2
Dowel and feet remain in sagittal plane	2
Dowel contacts maintained	2
Dowel remains vertical	2
No torso movement noted	2
Shoulder[f] (8 points possible)	
Right	
Fists are within one hand length	4
Fists are within one-and-a-half hand lengths	2
Fists are not within one-and-a-half hand lengths	0
Active impingement	+/−
Left	
Fists are within one hand length	4
Fists are within one-and-a-half hand lengths	2
Fists are not within one-and-a-half hand lengths	0
Active impingement	+/−
Active straight-leg raise[g] (12 points possible)	
Right	
Malleolus resides between mid-thigh and ASIS	6
Malleolus resides between mid-thigh and joint line	2
Malleolus resides below joint line	0
Left	
Malleolus resides between mid-thigh and ASIS	6
Malleolus resides between mid-thigh and joint line	2
Malleolus resides below joint line	0
Trunk stability push up[h] (12 points possible)	
Men	
Thumbs at forehead level	12
Thumbs at chin level	5
Failure at chin level	0
Women	
Thumbs at forehead level	12
Thumbs at chin level	5
Failure at chin level	0
Extension clearing	+/−
Rotary stability[h] (12 points possible)	
Right	
Unilateral repetition	6
Diagonal repetition	2
Failure of diagonal repetition	0
Left	
Unilateral repetition	6
Diagonal repetition	2
Failure of diagonal repetition	0
Flexion clearing test	+/−

[a] If pain is associated with any portion of the text or if the associated clearing test is positive, the participant received a score of 0 for the entire test (left and right).
[b] Test without board first. If all test criteria are not met, use board and score as indicated below.
[c] If participant is unable to complete any of the parameters with his or her heels on the board, a total score of 1 is awarded.
[d] Named according to moving leg.
[e] Named according to forward leg.
[f] Named for top hand.
[g] Knee is straight, ankle is neutral, opposite knee is on board.
[h] Lumbar is neutral.

tests that have a left and right component are scored independently for each side, and then the score is summed for the total score on the test. Separating the tests in this manner allows for greater precision so that the researcher

TABLE 2

Mean Values for 100-Point FMS in Middle School–age Children (N = 30)

FMS TESTS	MEAN±STANDARD ERROR	MAXIMUM POSSIBLE SCORE
Deep squat	4.9±0.5	18
Hurdle step, right	6.4±0.2	9
Hurdle step, left	6.5±0.2	9
Inline lunge, right	8.2±0.3	10
Inline lunge, left	7.1±0.5	10
Shoulder mobility, right	3.6±0.2	4
Shoulder mobility, left	3.2±0.2	4
Active straight-leg raise, right	4.3±0.4	6
Active straight-leg raise, left	4.1±0.4	6
Push up	4.8±1.0	12
Rotary stability, right	2.1±0.3	6
Rotary stability, left	1.9±0.3	6
Composite score	57.2±1.9	100

Abbreviation: FMS, Functional Movement Screen.

can identify the limiting component of the most limited movement pattern.

Statistical Analysis

Statistical analysis was conducted using interclass correlation coefficients (ICC) (2,1) to examine reliability between raters for each of the tests. Tests that exhibited bilateral components (inline lunge, hurdle step, rotary stability, active straight-leg raise, and shoulder mobility) had the reliability assessed for each side of the test. Reliability was also conducted on the composite FMS score. Initially, reliability was compared between the boys and girls for each of the subtests and the composite FMS score. Because no clinically relevant difference (operationally defined as ICC difference >0.10) was observed between sexes, the participants were combined to examine reliability of the measure. On completion of the reliability scoring, descriptive statistics were calculated for the right and left sides of the test, as well as the composite score. The descriptive statistics were calculated by averaging the scores of the raters and then averaging the scores from all performers for each test. All statistical calculations were performed by SPSS version 17 software (SPSS Inc, Chicago, Illinois). Acceptable reliability for the tests was established at 0.75.[23]

RESULTS

Thirty middle school-age students participated in the study and completed all of the tests of the FMS. Nineteen girls and 11 boys enrolled in the eighth grade participated in the study. The mean (±SD) height and weight were 1.68±0.15 meters and 55.8±2.6 kg, respectively.

The overall score on the FMS for the group was 57.2±10.3 of 100 (Table 2). Relative to the maximum score for each test, the participants performed best on the shoulder mobility and lunge tests. In contrast, the participants had the lowest scores, relative to the maximum score, for the rotary stability and deep squat tests. Bilateral comparison for all of the tests that examined movements for the right and left sides revealed no clinically meaningful difference in performance, on average.

Interrater reliability for all tests was high (Table 3). The ICC (2,1) value for the overall score was 0.99. For all tests, the ICC (2,1) value ranged between 0.91 and 1.00. The largest bilateral difference in ICC (2,1) values was for the lunge, where the right side reported an ICC value of 0.98 and the left side reported an ICC value of 0.91. The left and right shoulder mobility, left and right active straight-leg raise, and trunk stability push up all had perfect agreement of 1.0.

DISCUSSION

Functional movement testing is gaining popularity as an evidence-based and efficacious method of screening individuals for elevated injury risk. The initial derivation of the FMS has been determined to provide a reliable and valid method of assessing injury

TABLE 3

Interclass Correlation Coefficients for All of the Different Tests of the 100-Point FMS Scoring System (N = 30)

FMS TESTS	ICC (2,1)
Deep squat	0.99
Hurdle step, right	0.99
Hurdle step, left	0.98
Inline lunge, right	0.98
Inline lunge, left	0.91
Shoulder mobility, right	1.00
Shoulder mobility, left	1.00
Active straight-leg raise, right	1.00
Active straight-leg raise, left	1.00
Push up	1.00
Rotary stability, right	1.00
Rotary stability, left	1.00
Composite score	0.99

Abbreviations: FMS, Functional Movement Screen; ICC, intraclass correlation coefficients.

risk. The primary limitation of the FMS is that it does not identify the specific limiting factor underlying each score. As a result, the 100-point FMS scale has been developed to increase the precision of the instrument, which may be beneficial in a research and clinical setting. It is hoped that the development of the 100-point scoring system for the FMS will serve in a similar way to identify injury risk and provide additional direction regarding intervention strategies to remediate deficient movement patterns. On the basis of the results of this study, it appears that the 100-point FMS is reliable between raters and thus can be used consistently between different providers who are trained in use of the FMS.

The composite score of the 100-point FMS, along with each of the tests, exhibited high interrater reliability. Most reliability scores were greater than 0.97, with the exception of the lunge on the left side. After reviewing the protocol of the testing, there does not seem to be a systematic reason for the lower reliability of this measurement. It is interesting to note that the standard error of the mean for the lunge on the left side was higher than the lunge for the right side. The increased variability of the measurement may have led to the increased variance in the interpretation of the movement and thus the lower correlation coefficients. However, it is worth noting that the reliability of the lunge on the left side (ICC [2,1] = 0.91) is still high and is acceptable for clinical use.

High levels of reliability were observed previously in scoring the 21-point FMS. It is difficult to make direct comparisons with the previous study[19] on the 21-point FMS because reliability on the 21-point FMS was assessed using the weighted Kappa statistical test. However, comparisons can be made regarding the levels of agreement. In general, it appears that the systematic approach of scoring each component as used in the 100-point FMS scoring system improved the agreement between the raters. This may be due to the need to formally score each portion of the movement, thereby increasing the consistency of the protocol. Similar to the 100-point FMS, the test that scored with the lowest level of agreement on the 21-point FMS was the lunge on the left side. The fact that this phenomenon has been observed in 2 separate studies suggests that the lower reliability on the left side lunge may be a result of the stability of the participants' performance rather than any systematic issue with the scoring system.

Although the 100-point FMS scoring system was shown to be reliable, some limitations should be noted. Video reliability tends to inflate reliability scores because reviewers are able to watch the test multiple times; however, in our study, the raters typically only watched the videos 1 to 2 times. In addition, this study did not examine whether potential instability of a participants' performance on the test because test-retest reliability was not performed. The primary limitation of using the 100-point FMS as an efficacious clinical measurement is that it relies on video-based assessment of the performance. Although the limitation of videotape was acknowledged prior to implementation of the study, we thought it was a necessary factor to control to remove potential variance in the measurement. The total time for test completion and video analysis was 25 minutes (15 minutes for screening and 10 minutes for video analysis).

To improve its clinical application, the next step for this measure is to assess the reliability of the 100-point FMS during live, real-time assessment. It has been suggested by experienced testers that reviewing each item on the 100-point screen may actually improve overall reliability. Additional study is required to determine whether improved precision and reliability is observed in a real-time setting while maintaining the efficiency of the screen (<15 minutes). Another important aspect to note is that the raters used in this study had formal training on the FMS. Therefore, the results of this study should not be extrapolated to individuals who have not been formally trained in this measurement technique.

CONCLUSION

The 100-point FMS is a reliable measurement tool when comparing scores between raters who have completed formal training on the FMS. The authors encourage those performing research using the FMS to adopt the 100-point scoring system to improve precision. Also, from a clinical standpoint, it is helpful to score the individual components of the movement so that interventions can be targeted toward the weakest link of the movement. This breakdown of the movement pattern will allow future studies to assess how specific interventions can promote optimal total body movement patterns. Future studies should also determine whether a cut-score for elevated injury risk exists with the 100-point FMS and whether scores on the subtests can be correlated with prevalence of specific injuries.

IMPLICATIONS FOR CLINICAL PRACTICE

The FMS is reliable if it is broken down into its respective components and assigned to a 100-point scale. Use of the 100-point scale may be beneficial to clinicians in recalling what specific movement limitations exist so that specific corrective exercises can be targeted to remediate faulty movement patterns. ■

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