AN ASSESSMENT OF THE INTRA AND INTER-RATER RELIABILITY OF THE FUNCTIONAL MOVEMENT SCREEN ™

DANIEL MEEK

A thesis submitted in partial fulfillment of the requirements of Liverpool John Moores University for the degree of Master of Philosophy

October 2013

Contents:

1 - Abstract:

The aim of this thesis is to comprehensively investigate the reliability of the Functional Movement Screen ™ (FMS). The study presents the findings of a comprehensive reliability study, which demonstrates differences between the intra- and inter- rater reliability of the FMS. The intra-rater reliability of the FMS shows excellent levels of agreement (0.86), while the inter-rater reliability shows moderate levels of agreement (0.57). Further analysis shows that certification status of raters does not affect the reliability, with both certified and non certified raters showing very similar levels of agreement (0.57 & 0.56). In conclusion, a single rater should use the FMS over time to assess subjects in order to maintain reliable data. Comparing athletes using a variety of raters should be avoided, and where possible in-service training sessions should be provided to raters in order to ensure rating is as similar as possible. This thesis adds much needed research into the understudied area of FMS reliability, while providing practical advice that will benefit practitioners who utilise the FMS in their practice.

2 - General Introduction

The Functional Movement Screen (FMS) is an evaluation tool that is designed to evaluate whole body movement patterns of an individual during a number of specific tests designed to assess movement function. Subjects are asked to complete 7 movement tests that assess a variety of movement components, utilising combinations of joint stability and mobility, in order to assess movement efficiency.

Practitioners are using the FMS, however often without the appropriate training in order to be classified as a 'certified FMS expert'. Often practitioners learn the basic principles from a certified FMS expert and then have an understanding of how to use the FMS. This is usually due to a vast knowledge of functional human anatomy and an appreciation of the biomechanical components of human movement.

As practitioners may attempt to implement the use of the FMS within their screening protocols, they do so with a lack of substantial evidence supporting both the intra and inter rater reliability of the FMS. To date, there are only 2 intra-rater reliability studies (Shultz et al., 2011; Teyhen et al, 2012) in the literature. Further searches have found that the inter-rater reliability of the FMS has also only been reported in 2 further investigations (Minick et al., 2010; Onate et al., 2012) with varying degrees of inter-rater reliability reported. Within these reliability studies, some used raters that either received non-descript FMS training or certified FMS experts, albeit with varying levels of experience. This would seem problematic given that the results of such studies indicated that not all the individual component tests are reliable. Most of the results use average results that indicate reliability, when in fact individual components can be unreliable and not highlighted, due to mean scores being used.

The primary aims will focus on evaluating the reliability of the FMS as an indicator of movement function. The intra and inter rater reliability will be established, while further comparison will be made between real time and video rating. Lastly the effect of rater certification/experience status on reliability will also be assessed.

3 - Literature Review

The Functional Movement Screen

The functional movement screen (FMS) is an evaluation tool that attempts to assess the fundamental, whole-body, movement patterns of an individual (Cook et al., 2006). It is a combination of movements designed to test elements of mobility and stability in both the upper and lower extremities. Subjects are required to perform each test in the same order each time they undertake an assessment. The screen involves the following tests: Deep squat, Hurdle Step, In-Line Lunge, Shoulder Mobility, Active Straight Leg Raise, Trunk Stability and Rotary Stability. Raters score subjects on a scale of 0-3 depending on the efficiency of movement they demonstrate. A score of 0 is given if the subject feels pain at any point during the movement. If this outcome is obtained it is recommended they visit a physiotherapist. A score of 1 is attributed if the subject exhibits an incomplete movement with a score of 2 credited to the subject if they complete the movement but compensate in some way. A score of 3 is attributed to the subject if they complete the movement and display no compensation in doing so. The screen is supposed to evaluate the ability of an individual's joints and limbs to act synergistically in the generation of locomotor movements.

The FMS has been used in an attempt to analyse fundamental movement patterns (Kiesel et al., 2007; Kiesel et al., 2011). The available research on the FMS has focused mainly on correlating FMS scores with injury rates within American sports. It has been theorised from this work, that lower FMS scores are associated with an increased risk of injury (Kiesel et al., 2007) with the researchers concluding from their study that a composite FMS score below 14 would predispose an athlete to an increased risk of injury (Kiesel et al., 2007). This interpretation has been applied irrespective of the specific athletic subject group. Other FMS related research in this area on American football players shows that the FMS could also predict injury within this specific subject group. This adds further support to the suggestion by (Kiesel et al., 2007). Further research in this area has therefore aimed to provide athletes with individualized corrective programmes in an attempt to improve their FMS score, and subsequently reduce their risk of injury (Kiesel et al., 2011). Most of this work was however conducted with little follow up research to ensure that the FMS provided a repeatable, reliable system that could be used to accurately determine athlete's injury risk.

Reliability

As with all tests that provide subjects with a subjective assessment or score, there needs to be a good level of reliability in order for the test to be considered useful. Procedures that assess movement also require this key characteristic. It is reliability that enables the tests to consistently measure results and to provide some certainty that when evaluations are made over time that the change in any recorded results are changes that are "real" changes as opposed to random or systematic error. The majority of the previous literature on FMS has utilised different methodologies, and included no clear indication of the set measurement protocol to follow to obtain movement data. This makes it difficult to understand which protocols provide the foundation on which to understand the true reliability of the FMS.

The reliability of the FMS has been assessed in both civilian (Minick et al., 2010; Onate et al., 2012) and military populations (Teyhen et al., 2010). There is no reliability research that has used elite athletes. This is an important omission from the literature base as this population may demonstrate movement characteristics that are different from non-elite populations. Other research has assessed the reliability of movement screens that use many of the same individual tests as those included in the FMS (Frohm et al., 2012) and found similar levels of reliability. For example, Minick et al., (2010) found that 14 of the 17 individual tests had an excellent level of reliability. Onate et al., (2012) found that 6 of the 7 main tests had a substantial level of agreement. On the whole then it would seen that all the research to date has suggested that the FMS has good levels of reliability. While these conclusions look comprehensive it can be observed that the screening procedures were not carried out using similar methodological approaches. This makes it very difficult to accurately determine the appropriateness of the evidence to support the information generated by the research and hence the effectiveness of the FMS use in evaluating movement function.

Issues with current methodology

The first study to investigate the reliability status of the FMS was authored by those who actually designed the FMS concept as well as all the scores, instructions and theories associated with it. The study by Minick et al., (2010) found that the FMS has good levels of reliability and can be consistently used to rate subjects over time. However, a close analysis of the methodology used within the study highlights on some interesting points. The 2 FMS inventors were used within the study as the "expert" raters (defined as having over 10 years experience with the FMS), while there were 2 other "novice" raters (defined as having taken the course and used FMS for less than a year) also included in the investigation. When we compare the agreement scores of the raters the 2 novice raters had better agreement with each other than the 2 expert raters. The expert raters only showed over 90% agreement on 6 of 17 tests. These results were not however the results used for the statistical analysis to verify the reliability of the FMS. The authors took the average scores of the 2 expert raters and compared them to the average scores of the 2 novice raters. This may indicate that the approach to the analysis of the data was not an accurate representation of the agreement between the ratings.

This analytical interpretation of the available data highlights the need to address the limitations within the FMS reliability research. Further in depth analysis into the current reliability studies show there is little consistency in the way that the rating took place. A key element that is not clearly addressed in many of the reliability studies is the approach used to perform the actual rating (i.e. the use of video or actual live rating). One reliability study allowed raters to view the assessments on a video that enabled each rater to pause the movement before indicating their opinion on the quality of the movement (Minick et al., 2010). Other subsequent reliability studies have used real time live rating as their chosen assessment method

(Onate et al., 2012; Frohm et al., 2012). Considering that those raters scoring subjects live cannot ask subjects to “pause” their movement The live viewing method does not allow for superior or consistent viewing angles, which can lead to raters potentially missing key issues that may have been captured via video if it was used. There would seem to be some potential for some bias around these investigations. It would therefore seem pertinent to ensure that investigations of this nature include some clarity around how scoring should take place. Preliminary findings (Shultz et al., 2011) from studies that have used both approaches more systematically have shown that video and real time rating may be used interchangeably though the detail of the research is sparse. This key area needs to be addressed. As a consequence it is not known if the viewing method affects the reliability of the FMS, and there is currently no guidance offered within the literature suggesting how viewing should be performed.

Other key issues surrounding the methodology of previous studies concern the instructions given to subjects. It is not known how subjects were informed of the test procedures. This lack of information could potentially cause impact the reliability levels observed in research. In one of the studies, subjects were given instructional cues about their performance so that they improved upon their movement each time they repeated a repetition of a test (Frohm et al., 2012). Although this may help subjects attain good scores it makes a comprehensive assessment of its reliability difficult.

The aims of this thesis have been developed in order to answer the issues surrounding the current issues with the methodology of the FMS reliability studies. These aims include assessing the intra and inter reliability of the FMS utilising a number of raters and viewing method.

4 - Chapter 1

4.1 - Introduction

The FMS has not been extensively researched in elite athlete populations, despite the increased use of the FMS within these subject groups. There are very few reliability studies (Minick et al., 2010; Teyhen et al., 2012; Onate et al., 2012;) of which none have utilised athletic populations. Of the reliability studies that have been published, all have used a slightly different methodology to draw their conclusions, with no gold standard method developed.

It has been established that the FMS is used in elite level sport (Kiesel et al., 2007; Kiesel et al., 2009), however the majority of the reliability research does not utilise elite athlete populations (Minick et al., 2010; Onate et al., 2012; Teyhen et al., 2012). It is vitally important that if the FMS is utilised within elite sport, that reliability studies employing a variety of athletes from a variety of athletic sports need to be conducted in order for the screening process to applied across elite athlete populations.

The FMS has been shown to have good levels of both intra-rater (Shultz et al., 2011; Teyhen et al., 2012) and inter-rater (Minick et al., 2010; Onate et al., 2012) reliability in terms of individuals overall composite scores. However, when looking into more detail, there appears to be possible reliability issues with certain individual FMS tests such as the lunge and hurdle step (Onate et al., 2012; Minick et al., 2010; Teyhen et al., 2012). These tests may not possess consistent reliability, as with the other individual FMS tests (Minick et al., 2010; Onate et al., 2012). This may be due to subjects not understanding verbal instructions provided for them, as both are fairly complex movements with multiple cues to follow during the movements.

The methodology of the FMS research appears to show no evidence that a demonstration was used, or that subjects could view pictures/performances of perfect FMS performance (Minick et al., 2010; Onate et al., 2012; Teyhen et al., 2012). Without this information and visual representation it may have inhibited subjects ability to understand what was being asked of them. As such the reliability issues may not have been due to rater performance, but rather incorrect technique that may have been difficult to accurately score.

Further analysis of the reliability studies fails to distinguish between raters who are certified to use the FMS, and those who are not. In the reliability studies (Minick et al., 2010; Teyhen et al., 2012; Onate et al., 2012) a variety of certification levels and experience levels have been used. Again, with no gold standard there is a lack of direction regarding whether certification status and/or experience of raters affects reliability.

The aim of the reliability study within this chapter is to establish both the overall composite FMS reliability, and the reliability of the individual components of the FMS. This will be completed via the following objectives. Firstly, method agreement between real time and video will be established to ensure that video rating can be used as a method of assessment. Secondly, Intra-rater reliability will be established. Thirdly, inter-rater reliability will be established utilising the principal rater and 2 other raters, one certified, one uncertified, in order to assess the effects of certification on reliability. The last objective of this chapter is to establish a gold standard instruction format for subjects, in the form of a demonstration video that provides subjects with written, verbal and visual representation of perfect FMS performance.

4.2 - Method

Subjects

Eighteen subjects (Age: 22 ± 2 years, Height: 177.4cm ± 10.12cm, Weight: 78.2 ± 11.5kg, 15 males and 3 females), were recruited to take part in the study. All were physically fit and competed in their sport at international and national events. Subjects participated in a variety of sports including rugby league, boxing, swimming and weight lifting. All subjects were performing the FMS for the first time, though some were familiar with medical screening procedures that tested for movement deficiencies. Subjects gave their informed consent, and the experimental procedures were approved by the Liverpool John Moores University ethics board.

Study Design

The study was designed in order to test the method agreement, intra-rater and inter-rater reliability of the Functional Movement Screen. Method agreement comparisons were made between real-time assessments of the FMS and evaluation utilising video playback of the screening session. This assessment was undertaken to evaluate the agreement between video scores and real-time viewing scores. This was undertaken so that researchers could be sure that video was a reliable method to use for assessment purposes in future chapters in this thesis. The principal rater scored all participants in real time and then again using video 72 hours after the initial real time screening. Three raters in total were used for the inter-rater comparisons. Two raters were certified FMS specialists. The other was not certified. The experience of the certified raters was between 4 and 24 months. The non-certified rater was a strength and conditioning coach who had used the FMS screen for around 24 months but had never taken the certification exam. This rater was included to observe the effect of certification on rating consistency/ability.

Procedure

On arrival participants were told to wait outside the laboratory and sign the consent form required to participate in the study. All subjects wore shorts and a t-shirt/vest top as instructed. Positions were marked on the floor using tape to ensure the principal rater did not obstruct the view of the camera. This was for the benefit of the rater during the video observations. The subjects used markers placed on the floor to ensure they were standing in the correct position when performing each test. This helped maintain the perpendicular and parallel angles for the cameras. Subjects were positioned in front of a projector screen so they could read the instructions and view the image of the movement on the demonstration video. Subjects were shown the instructions and a video demonstration of the correct movement required before each of the 10 tests.

No other published study involving the FMS has clearly outlined the guidelines that were given to the subjects completing the FMS. A demonstration video was therefore developed in order to describe and show the subjects how to correctly perform the FMS tests in this investigation. This prevented any coaching or cueing from taking place during the evaluation as coaching may bias the outcome. The video showed a visual representation of each test as well as a written description of the movement as per the official instructions of the FMS. All raters involved in the research were consulted and subsequently agreed that the demonstrations included in the video were suitable for the demonstration of "excellent" technique in each test. This was crucial to ensure that the subjects were aware of what is expected of a "perfect" movement in each of the screens component tests.

The official instructions from the book "Movement: Functional Movement Systems" (Cook et al., 2010) were initially shown on the video for each test (appendix A). This was followed by a visual video demonstration of the movement. The video included a "test movement" that was not included in the screen to ensure the subjects understood the terminology used in the instructions and were given an opportunity to ask questions. This test movement was not scored by raters. This movement is not included in the screen. Each subject read the slides, and then viewed the demonstrations of the movement, before commencing any actions. Each video of the individual test being performed was shown 3 times to minimize any potential misunderstanding of the movement. The video was paused after each test demonstration to allow the subject to complete the required test. Subjects were cued into the correct technical position to begin each test and were given no further instructions other than to complete each test 3 times.

The first test in the FMS screen is the deep squat (Figure. 1). The Deep squat test assessed bilateral, symmetrical and functional mobility of the hips, knees and ankles. The closed kinetic chain movement is supposed to challenge whole body movement especially with the use of the dowel overhead.

Figure 1. Illustration of the exercise “Deep Squat” from the FMS.

Participants then completed the hurdle step test (Figure. 2). This test is supposed to evaluate the participants stride mechanics. The movement requires coordination and stability between the hips and torso as well as single leg stability. The hurdle step required a combination of closed chain extension of the hip and open kinetic chain movement at the ankle, knee and hip of the moving leg. The test enabled the participants to exhibit a combination of bilateral mobility and stability of the hips, knees and ankles.

Figure 2. Illustration of the exercise “Hurdle Step” from the FMS.

Participants then completed the in-line lunge test (Figure. 3). The test is supposed to assess torso, shoulder, hip and ankle mobility and stability. This combined with quadriceps flexibility and knee stability. The rotational stress imposed on the participant meant that they had to display stability to successfully complete the test.

Figure 3. Illustration of the exercise “In-Line Lunge” from the FMS.

Participants then completed the shoulder mobility test (Figure. 4). This test is intended to evaluate combined shoulder internal and external rotation with abduction and adduction. The test also required thoracic and scapular mobility.

Figure 4. Illustration of the exercise “Shoulder Mobility” from the FMS.

Participants were then required to perform the active straight leg raise (Figure. 5). This test is alleged to require participants to disassociate the moving lower extremity while maintaining torso stability. A stable pelvis and active extension in the non-moving leg was required while the hamstring flexibility of the moving leg was assessed.

Figure 5. Illustration of the exercise “Active Straight Leg Raise” from the FMS.

Participants were then instructed to perform the trunk stability test (Figure. 6). This test is supposed to measure the ability of the participants to stabilise the spine in both an anterior and posterior plane. It requires the stabilisation of the torso during an upper-extremity movement.

Figure 6. Illustration of the exercise “Trunk Stability Push Up” from the FMS.

The last test participants were asked to complete was the rotary stability test (Figure. 7). This test is supposed to measure the participant’s ability to exhibit multi-plane trunk stability during a combined upper and lower extremity motion. The ability to perform this test requires trunk stability in the transverse and sagittal planes during the movement.

Figure 7. Illustration of the exercise “Rotary Stability” from the FMS.

The FMS screen involves three clearing exams to test for pain in basic movements that can affect the outcome of the shoulder mobility, trunk stability and rotary stability tests. The three clearing exams (Figures. 8-10) were not used for comparison between raters; but were used to assist scoring. They were performed after the shoulder mobility, trunk stability push up and the rotary stability test. A positive score in any of the clearing tests is indicative of pain in the movement and a score of zero was subsequently assigned to that test.

Figure 8. Illustration of the clearing exam “Shoulder Impingement” from the FMS.

Figure 9. Illustration of the clearing exam “Spinal Flexion” from the FMS.

Figure 10. Illustration of the clearing exam “Spinal Extension” from the FMS.

Participants were scored during the screen in real time by the principal rater. Once they had completed three repetitions of each test the score was recorded. The scoring system used in the research was identical to the scoring used in all FMS screening. A score of 3 was given to subjects who completed the movement as described (appendix B). A score of 2 was given to subjects who showed some type of compensation when completing the movement (appendix B). A score of 1 was attributed if the subject was unable to complete the movement pattern as described (appendix B). A score of zero was given if the subject felt any pain during the movement and notified the rater accordingly.

Subjects were not allowed to see each other performing the tests or discuss their personal scores with FMS raters. Individual scores were recorded on the official marking sheets and collated at the end of each individual screen by a research assistant and not the rater involved; in accordance with the consort statement (Altman et al., 2001). The rater involved in the research did not handle any data collection sheets after successfully rating each subject. The mark sheets used were set out as per the official guidelines (appendix C). Marking was conducted in agreement with the official marking criteria (appendix B). As subjects performed the FMS test they were filmed using Canon video cameras (Canon Inc, Japan), positioned on tripods, from both the frontal and sagittal planes. Each subject performed the FMS screen, including the clearing exams in the correct sequence (appendix 1).

Following the completion of the real time rating the principal rater then watched the video of each subject's FMS performance, in a randomised order, 3 days and 7 days after the original testing day. The randomised order was taken from a statistics book with random numbering guides. This randomised order was used to minimise the rater recalling scores from memory due to the same order being used. The videos were run next to each other, on the same computer screen, to test for intra-rater reliability. This was done to ensure that raters could observe both parallel and perpendicular views simultaneously. The videos were then shown to the 2 other raters to test for inter-rater reliability. The videos were shown exactly how the rater saw the screen in real-time and in the same order (Figure. 2). No pausing of the video took place and the video of the screen was not edited in any way. This enabled the video to be as similar to real-life as possible.

Statistical Analysis

Kappa statistics were calculated for each test between the raters scores. The Kappa test is a measure of "true" agreement, beyond what is expected by chance. (SPSS, Chicago, USA). Firstly the intra-rater reliability was assessed to ensure the video was acceptable to use for rating. Then further kappa tests were used to test for inter-rater reliability. The tests were analysed by comparing the kappa values of both the individual left and right sides for each of the 7 tests performed. The kappa scale used was taken from Landis & Koch (1977).

- 1.0 – 0.81 Excellent
- 0.8 – 0.61 Substantial
- 0.6 – 0.41 Moderate
- 0.4 – 0.21 Fair
- 0.2 – 0 Poor

Within the current literature it is suggested that having an FMS score <14 predisposes subjects to injury risk with those who score above >14 being at a lower risk of injury. Due to the sensitive nature of the scores and an understanding that a subjects overall movement assessment can be classified differently based on their overall score changing by +/- 1, it is important to note that kappa scores should be ≥ 0.81. This would ensure that these changes are sensitive enough to be detected by raters. It is therefore vital to ensure that the agreement be classified as “excellent” in order for the FMS to be considered reliable.

4.3 - Results

Method Agreement

The results of the method agreement tests suggest that video and real time assessment can be used interchangeably with good levels of agreement (Table 1). Our results would therefore seem to suggest that video playback may be used as an effective alternative assessment method for the functional movement screen. The scores for the Lunge Right, Trunk, and both ASLR Left and Right were below the substantial level of agreement. The shoulder left test showed perfect agreement. As you can see from Table 2, only one score of the 18 squat tests was not the same.

Table 1. Method agreement Kappa scores for Principal rater between Real time (RT)

Test	**RT * Video Kappa Score**	**Level of agreement**
Squat	0.91	Excellent
Hurdle Step Left	0.83	Excellent
Hurdle Step Right	0.83	Excellent
Lunge Left	0.90	Excellent
Lunge Right	0.67	Substantial
Shoulder Left	1.00	Excellent
Shoulder Right	0.88	Excellent
ASLR Left	0.49	Moderate
ASLR Right	0.56	Moderate
Trunk	0.79	Substantial
Rotary Stability Left	0.92	Excellent
Rotary Stability Right	0.84	Excellent
AVERAGE	**0.80**	**Substantial**

and Video (V)

Table 2. Agreement on the Squat Test between RT & Video of the principal rater

RT / **Video**	*0*	*1*	*2*	*3*
0	*1*			
1		*1*		
2		*1*	*9*	
3				*6*

Intra-Rater Reliability

Intra-rater reliability was then assessed using the video at two different time points (Table 3). The principal rater had perfect agreement on 5 of the 12 tests (hurdle step left and right, ASLR left and right and trunk stability push up) (Table 3). There was substantial to excellent agreement on all other tests except the right shoulder where there was only a moderate level of agreement.

Table 3. Principal Rater kappa scores between 2 video viewing session

Test	**V 3 days * V 7 days post RT**	**Level of agreement**
Squat	0.83	Excellent
Hurdle Step Left	1.00	Excellent
Hurdle Step Right	1.00	Excellent
Lunge Left	0.71	Substantial
Lunge Right	0.66	Substantial
Shoulder Left	0.71	Substantial
Shoulder Right	0.59	Moderate
ASLR Left	1.00	Excellent
ASLR Right	1.00	Excellent
Trunk	1.00	Excellent
Rotary Stability Left	0.92	Excellent
Rotary Stability Right	0.84	Excellent
AVERAGE	**0.86**	**Excellent**

Table 4. Agreement on the squat test between the 2 video viewings of the principal rater

Video 1 / **Video 2**	*0*	*1*	*2*	*3*
0	*1*			
1		*2*		
2		*2*	*7*	
3				*6*

Inter-rater Reliability

The kappa scores for the inter-rater reliability were considerably lower than those for intra-rater reliability. The majority of tests had a moderate to substantial level of agreement, with only the squat test scoring an excellent level of agreement (0.84). The average Kappa score was 0.29 lower than that seen for the intra-rater reliability scores. As can be seen in Table 6, the rotary stability Left produced very low levels of agreement.

Table 5. Inter-rater reliability Kappa scores comparing Principal rater (PR) and certified rater (CR)

Test	**PR *CR**	**Level of agreement**
Squat	0.84	Excellent

Hurdle Step Left	0.61	Substantial
Hurdle Step Right	0.13	Slight
Lunge Left	0.52	Moderate
Lunge Right	0.46	Moderate
Shoulder Left	0.69	Substantial
Shoulder Right	0.70	Substantial
ASLR Left	0.71	Substantial
ASLR Right	0.64	Substantial
Trunk	0.68	Substantial
Rotary Stability Left	0.37	Fair
Rotary Stability Right	0.52	Moderate
AVERAGE	**0.57**	**Moderate**

Table 6. Agreement on the Rotary Stability Left test between the Principal Rater and Certified rater

PR / **CR**	*0*	*1*	*2*	*3*
0				
1	*1*	*3*		
2		*4*	*3*	*2*

3		*1*	*1*	*3*

Further inter-rater analysis compared the results of the principal rater with a non-certified rater (Table 7). This analysis was carried out in order to assess the effects of certification status on reliability. When comparing the scores of both raters, none of the levels of agreement reached excellent and 5 of the tests only had a fair level of agreement. The average Kappa score for the comparisons between the principal rater and non-certified rater was 0.56. This average score is only 0.01 lower than the kappa level of agreement for the certified rater's inter-rater comparison (Table 9).

Table 7. Kappa scores comparing Principal rater (PR) and non certified rater (NCR)

Test	**PR *NCR**	**Level of agreement**
Squat	0.77	Substantial
Hurdle Step Left	0.39	Fair
Hurdle Step Right	0.70	Substantial
Lunge Left	0.65	Substantial
Lunge Right	0.37	Fair
Shoulder Left	0.55	Moderate
Shoulder Right	0.39	Fair
ASLR Left	0.73	Substantial
ASLR Right	0.72	Substantial

Trunk	0.78	Substantial
Rotary Stability Left	0.31	Fair
Rotary Stability Right	0.31	Fair
AVERAGE	**0.56**	**Moderate**

Table 8. Agreement on the squat test between the Certified and non-certified rater.

CR / **NCR**	*0*	*1*	*2*	*3*
0	*1*			
1		*5*		
2		*2*	*4*	*1*
3				*5*

Table 9. Average Kappa scores for all raters video scores

	Inter-Rater Reliability		Intra-Rater Reliability
	PR * CR	PR * NCR	
Average Kappa Scores of all components	**0.57 (Moderate)**	**0.56 (Moderate)**	**0.86 (Excellent)**

4.4 - Discussion

There were three main objectives associated with this chapter. Firstly, the method agreement was established between real time and video assessment. This was completed to evaluate if video provided a suitable alternative to real time assessment. The intra-rater reliability was also assessed to determine the reproducibility of the movement screen. The final aims were to compare the inter-rater reliability, as well as examine the influence of certification on the level of agreement of movement assessments. From our results it is clear that video can be used as an effective alternative assessment method to real time viewing. This means that practitioners could use either method with confidence to produce evaluations of an individual's movement function. The intra-rater reliability of the FMS was excellent with kappa scores reaching the desired level of agreement (0.86). This outcome would indicate that the same rater can produce comparable results for movement screens. Inter-rater reliability was, however, classified as being moderate in terms of agreement (0.57). This result suggests that caution should be applied to using multiple raters during one off assessments of athletes or during interventions aimed at improving movement function. It would be advised that the utilization of multiple raters should be avoided if possible. The additional analysis shows that certification status made very little difference to the inter-rater reliability between individuals, suggesting that certification in itself might not cause ratings to be more reliable. These outcomes collectively would seem to indicate that the FMS provides consistent data on the movement function of athletes if careful attention is given to both the individuals that are used to provide the rating and the methodological approach used to generate the assessed movements. As such it might be a useful tool in the monitoring and implementation of movement related training programmes in athletes.

The results provided in the current investigation indicate that video assessment of the FMS can be used as an alternative to real-time (RT) viewing. These results support previous research by Shultz et al., (2011). These data are important, as it is clear that the application of video assessment would help streamline the FMS data collection process. Using video would mean that less time and attention would be required from the assessor during the live performance of the screen during the data collection. This may make it more feasible to assess larger athlete groups and hence generate data for coaches and other practitioners more time efficiently. The use of video will also provide an opportunity to keep a permanent record of an athlete's movement function. This may be useful in the future for other monitoring approaches. Such outcomes as observed here may, however, only be obtained if the filming for the video analysis is completed in a specific way. Filming of both the frontal and sagittal planes, as in this investigation, allows for superior views of the athletes movement to be obtained when compared to real-time analysis. This would indicate that multiple cameras are important during data collection. This may prove prohibitive to individuals and organisations that have limited filming resources. Future work could examine the influence of other filming procedures on video assessments. Such data may provide a platform for more efficient data collection strategies for a range of practitioners in the future.

The intra-rater reliability evaluation indicated that in the context of the current investigations methodology that the FMS is a reliable tool when used by a single rater. This supports other currently available (though limited) research, which shows that intra-rater reliability of the screen is good (Shultz et al., 2011; Teyhen et al.,2012). Of the 21 tests included in the FMS, 5 demonstrated a perfect intra-rater agreement. These tests include the active straight leg raise, trunk stability and the hurdle step. In previous research, the hurdle step has been highlighted as a test that generally has poor levels of agreement (Onate et al., 2012). This discrepancy could be due to previous research utilising real-time viewing, which could limit accurate assessment as a consequence of differing viewing positions of raters during analysis. This idea would be supported by our observation of slightly lower levels of reliability during RT viewing when compared to video viewing. In the current study, video recordings of both the frontal and sagittal planes were used in order to provide superior viewing angles. This would allow each rater to view from exactly the same position during the assessment. As a consequence the ability to observe the movement in full from different perspectives, may improve the ability to develop an accurate rating score and hence explain the improved reliability of the hurdle-step that is demonstrated here (Onate et al., 2012). Our data suggests that the FMS can therefore be confidently used within an athletic setting to evaluate the movement function in athletes if the same rater is used for each assessment session when utilising video recording of screens.

The inter-rater results indicate that the FMS has lower levels of agreement when comparisons are made between multiple raters than when a single individual is used. The inter-rater reliability between certified raters only reached a moderate level (0.573) of agreement when compared to the values (0.856) seen for the intra rater assessment. Previous research has suggested that the inter-rater reliability of the FMS is good, thereby indicating that multiple raters can provide consistent results (Minick et al., 2010; Onate et al 2012; Frohm et al., 2012). This would seem to contrast with the data that we have collected in the current investigation, as well as the findings of other previous research (Shultz et al., 2011). The inconsistency of the findings in the inter-rater reliability research of the FMS is something that should be noted for practitioners using the FMS. Although in its infancy, research into the reliability of the FMS needs to be further developed, for comprehensive conclusions to be drawn. Further in-depth research is needed to assess the inter-rater reliability of the individual components of the FMS and how they may individually affect the overall inter-rater reliability of the FMS as a whole.

The inter-rater reliability of the hurdle step and lunge tests in this study was poor when compared to most of the other tests in the screen. The poor inter-rater reliability in this investigation could therefore be a consequence of the outcomes of these specific tests as opposed to the screen generally. This could relate specifically to issues surrounding the clarity of these movements during assessment. Other authors have also found these two tests to exhibit the lowest kappa scores (Onate et al., 2012). This has been linked to the idea that the mid-range performances of the hurdle step and lunge test appear to be to be less clearly defined than other tests

(Minick et al., 2010). This lack of certainty regarding mid-range performance might lead to raters being unsure of the correct scoring outcome for the entire movement, and thus leading them inconsistent ratings. Interestingly, the poor reliability of these individual tests has been highlighted in studies that have found the FMS to be both reliable (Onate et al., 2012) and unreliable (Shultz et al., 2011) suggesting further research on these specific exercise is required in order to draw adequate conclusions.

The data from the current investigation, as well as previous research, shows that the FMS can be utilised consistently by a single rater over time. However due to the lack of consistent inter-rater reliability observed, questions remain regarding the continued use of the FMS as a multi-rater, globally utilised tool for reliable assessment of movement. Currently, due to the lack of conclusive supporting evidence for both the overall and individual test inter-rater reliability of the FMS, it is recommended clinicians avoid comparisons across multiple raters (Shultz et al., 2012). This might have implications for practitioners currently applying the principles of the FMS within sporting organisations.

Within sporting and fitness related organisations, , there are individuals performing functional movement screens on athletes/clients without the specific FMS certification. Within this study it was also possible to analyse the effects of certification on the consistency of rating scores. We assessed the inter-rater reliability between 3 different raters. Two of them had the appropriate certification while one of them was a professional physiotherapist who did not. The creators of the FMS suggest that those raters who are professionally certified would produce a better level of agreement when compared to those that had not been suitably trained. This would indicate that you may need to attend a paid certification course in order to be trained to utilise the FMS effectively. Analysis of our results demonstrates that the certification level of the rater did not seem to have a positive effect on the inter-rater reliability values of the FMS. The data showed that certification status made no difference to inter-rater reliability levels. It has been suggested that experience may be as important in determining professional competence as appropriate certification. Previous research has distinguished "novice" and "expert" raters by their level of experience (years practicing FMS), not certification status (Minick et al., 2010). We did not evaluate the experience of any of the raters included in our data collection. As a consequence it is not possible for us to evaluate the role of this factor as a co-variate in our data. Future investigations should attempt to evaluate the role of experience on inter-rater agreement. Experience and theoretical knowledge will be a vital factor in the production of consistent results, though this has not been investigated in any detail within FMS research. Certification enables practitioners to establish a baseline level of theoretical knowledge; however the number of FMS tests performed, and the general practical experience of the user, would be a key factor in determining inter-rater reliability levels. The results of the current study show that FMS certification does not lead to improved reliability. Experience and practical experience may, therefore, be a far more interesting variable to consider in future research to help inform practice within elite level sport.

The current study utilised a range of scores from a homogenous group of individuals. All those subjects involved were elite level athletes. It is vitally important that research continues to utilise elite level athletes within FMS research, as ultimately they are the individuals that would benefit from advances in research. A larger representative sample of elite level subjects may be required to advance the research of FMS reliability. This would provide a consistent subject group that may enhance the rating process. Further research focusing on the reliability of individual FMS components using larger samples is required, as currently there is much conflicting evidence regarding the reliability of individual FMS components (Shultz et al., 2011; Teyhen et al., 2012; Onate et al., 2012).

In conclusion, the current study indicates that the FMS, like many other observer subjective rating systems (Hopkins, 2000), is limited by poor levels of reliability when using multiple raters, but not when a single rater is used. Within practical settings, if a single rater cannot be used it is imperative to ensure that all raters agree on their interpretation of the scoring criteria as this may ensure consistent agreement across raters. It is recommended that in-service development courses are included in order to develop this agreement between raters and that it is as reliable as possible. This is vitally important as even the certification process does not affect the reliability shown by raters. This suggests that certification is therefore not necessary to be a reliable FMS rater. Due to the fact that FMS certification does not affect agreement reliability it is recommended that simply performing more FMS tests, and improving experience, will improve the quality and consistency of FMS rating.

The FMS is a reliable tool to use if a single rater utilises the screen and assesses the same subjects over time, as the intra-rater reliability of the FMS is good. It is advised however to avoid using multiple/different raters over time in order to assess movement function as inter-rater reliability of the FMS is poor. Furthermore practitioners should make themselves aware of the FMS procedures, however formal certification in its current form does not appear necessary in order to improve reliability of rating.

6 - Synthesis of Findings

Overall the results of the thesis support the more recent literature that shows the intra-rater reliability of the FMS is good and can be used confidently by one rater to observe changes in movement function (Shultz et al., 2011; Teyhen et al., 2012). Provided individual assessors are used to rate subjects longitudinally, any changes in FMS score would seem to be reliably attributed to fluctuations in movement function and not measurement error. There does, however, appear to be issues relating to the use of multiple raters as the inter-reliability evaluation in this study suggested that the data generated between raters is not as consistent as the data generated by one rater. It is therefore recommended that when dealing with same subjects over time, the same rater should perform the FMS test in order to obtain the most accurate data.

The findings show that even with the development of a demonstration video with clear, precise instructions and following correct procedure, the inter-rater reliability cannot be deemed satisfactory. This influences the practical application and delivery of the FMS in the real world. The lack of inter-rater reliability inhibits the ability of the FMS to remain a reliable measurement tool that can be applied across multiple raters, independent of rater certification status. The poor inter-rater reliability findings cast serious doubt about the interchangeability of raters. The certification process is designed to standardize rating and ensure the FMS is a reliable tool. It is recommended that multiple raters are not used due to the increased margin of error that is observed when using multiple raters. It is vital that during situations where multiple raters have to be used, there is an understanding that the margin for error in measurement will increase.

This research adds to the body of FMS research by further supporting the good levels of intra-rater reliability found in previous work. However, It does add weight to the research that shows the FMS to have poor inter-rater reliability. With a robust method, taking into account certification level and method of instruction to subjects,

Given the results of this thesis, future FMS reliability research should focus on observing the effects of experience of raters on reliability.

Utilising a much larger cohort of subjects from an elite athletic background would be advantageous, in order to fully assess the complete reliability of the FMS within elite athletic populations. It is vital that future research recruits larger cohorts in order to increase the statistical power of findings and add strong evidence to the growing body of FMS reliability research.

Conclusion

Through completion of the aims of this thesis it is concluded that the FMS should only be used by one rater at any one time in order to rate subjects over a consistent period of time. This is required in order to ensure adequate reliability of the data collected. Inter-rater reliability, independent of certification status, is considered poor and using multiple raters should be avoided.

7 - References

Ahmadi, A., Rowlands, D.D. & James, D.A. (2006). Investigating the translational and rotational motion of the swing using accelerometers for athlete skill assessment. *In Proceedings of the 5th IEEE Conference on Sensors, Korea*, 980-983.

Altman, D.G., Schulz, K.F., Moher, D., Egger, M., Davidoff, F., Elbourne, D., et al. (2001). The revised CONSORT statement for reporting randomized trials: explanation and elaboration. *Annals of Internal Medicine,* 134(8), 663-694.

Bangsbo, J. (1994). The physiology of soccer – with special reference to intense intermittent exercise. *Acta Physiologica,* 619, 1-155.

Bangsbo, J., Mohr, M. & Krustrup, P. (2006). Physical and metabolic demands of training and match-play in the elite football player. *Journal of Sports Sciences,* 24(7), 665-674.

Barbero-Alvarez, J.C., Coutts, A., Granda, J., Barbero-Alvarez, V. & Castagna, C. (2010). The validity and reliability of a global positioning satellite system device to assess speed and repeated sprint ability (RSA) in athletes. *Journal of Science and Medicine in Sport,* 13(2), 232-235.

Bloomfield, J., Polman, R. & O'Donoghue, P. (2007). Physical demands of different positions in FA Premier League soccer. *Journal of Sports Science and Medicine,* 6, 63-70.

Bradley, P., O'Donoghue, P., Wooster, B. & Tordoff, P. (2007). The reliability of ProZone MatchViewer: a video-based technical performance analysis system. *International Journal of Performance Analysis in Sport,* 7(3), 117-129.

Callaway, A.J., Cobb, J.E, & Jones, I. (2009). A comparison of video and accelerometer based approaches applied to performance monitoring in swimming. *International Journal of Sports Science and Coaching,* 4(1), 139-153.

Castellano, J., Casamichana, D., Calleja-Gonzalez, J., San Roman, J. & Ostojic, S.M. (2011). Reliability and accuracy of 10hz GPS devices for short-distance exercise. *Journal of Sports Science & Medicine,* 10, 233-234.

Cook, G., Burton, L. & Hoogenboom. B. (2006). Pre-participation screening: the use of fundamental movements as an assessment of function – part 1. *North American Journal of Sports Physical Therapy,* 1(2), 62-72.

Coutts, A.J. & Duffield, R. (2010). Validity and reliability of GPS devices for measuring movement demands of team sports. *Journal of Science and Medicine in Sport,* 13(1), 133-135.

Di Salvo, V., Baron, R., Tschan, H., Calderon-Montero, F.J., Bachi, N. & Pigozzi. F. (2007). Performance characteristics according to playing position in elite soccer. *International Journal of Sports Medicine,* (28), 222-227.

Drust, B., Atkinson, G. & Reilly, T. (2007). Future perspectives in the evaluation of the physiological demands of soccer. *Sports Medicine,* 37(9), 783-805.

Edgecomb, S.J. & Norton, K.I. (2006). Comparison of global positioning and computer-based tracking systems for measuring player movement distance during Australian Football. *Journal of Science and Medicine in Sport,* 9(1), 25-32.

Faude, O., Koch, T. & Meyer, T. (2012). Straight sprinting is the most frequent action in goal situations in professional football. *Journal of Sports Sciences,* 30(7), 625-631.

Fousekis, K., Tsepis, E. & Vagenas. G. (2010). Lower limb strength in professional soccer players: profile, asymmetry, and training age. *Journal of sports science and medicine*. 9, 364-373.

Frohm, A., Heijne, A., Kowalski, J., Svensson, P. & Myklebust, G. (2012). A nine-test screening battery for athletes: a reliability study. *Scandinavian Journal od Medicine and Science in Sports,* 22(3), 306-315.

Gray, A.J., Jenkins, D., Andrews, M.H., Taafe, D.R. & Glover, M.L. 2010. Validity and reliability of GPS for measuring distance travelled in field-based team sports. *Journal of Sports Sciences,* 28(12), 1319-1325.

Gregson, W., Drust, B., Atkinson, G. & Di Salvo, V. 2010. Match-to-match variability of high-speed activities in premier league soccer. *International Journal of Sports Medicine,* 31, 237-242.

Hawkins, R.D., Hulse, M.A., Wilkinson, C., Hodson, A. & Gibson, M. (2001). The association football medical research programme: an audit of injuries in professional football. *British Journal of Sports Medicine,* 35, 43-47.

Hill-Haas, S., Coutts, A., Rowsell, G. & Dawson, B. (2008). Variability of acute physiological responses and performance profiles of youth soccer players in small sided games. *Journal of Science and Medicine in Sport,* 11, 487-490.

Hill-Haas, S.V., Coutts, A.J., Dawson, B.T. & Rowsell, G.J. (2010). Time motion characteristics and physiological responses of small-sided games in elite youth players: the influence of player number and rule changes. *Journal of Strength and Conditioning Research,* 24(8), 2149-2156.

Hopkins, W.G. (2000). Measures of reliability in sports medicine and science. *Sports Medicine,* 30(1), 1-15.

Kellis, S., Gerodimos, V., Kellis, E. & Manou, V. (2001). Bilteral isokinetic concentric and eccentric strength profiles of the knee extensors and flexors in young soccer players. *Isokinetics and Exercise Science,* 9, 31-39.

Kiesel, K., Plisky, P. & Butler, R. (2011). Functional movement test scores improve following a standardized off-season intervention program in professional football players. *Scandanavian Journal of Medicine and Science in Sports,* 21(2), 287-292.

Kiesel, K., Plisky, P.J. & Voight, M.L. (2007). Can serious injury in professional football be predicted by a preseason functional movement screen? *North American Journal of Sports Physical Therapy,* 2(3), 147-158.

Kraemer, W.J., Torine, J.C., Silvestre, R., French, D.N., Ratamess, N.A., Spiering, B.A., et al. (2005). Body size and composition of national football league players. *Journal of Strength and Conditioning research,* 19(3), 485-489.

Kyrolainen, H, Komi, P.V. & Belli, A. (1999). Changes in muscle activity patterns and kinetics with increasing running speed. *Journal of Strength and Conditioning Research,* 13(4), 400-406.

Landis, J.R. & Koch, G.G. (1977). The measurement of observer agreement for categorical data. *Biometrics,* 33, 159-174.

McGill, S.M., Andersen, J.T. & Horne, A.D. (2012). Predicting performance and injury resilience from movement quality and fitness scores in a basketball team over 2 years. *Journal of Strength and Conditioning Research,* 26(7), 1731-1739.

Minick, K.I., Kiesel, K.B., Burton, L., Taylor, A., Plisky, P. & Butler, R.J. (2010). Interrater reliability of the functional movement screen. *Journal of Strength and Conditioning Research,* 24(2), 479-486.

Mohr, M., Krustrup, P. & Bangsbo, J. (2003). Match performance of high standard soccer players with special reference to development of fatigue. *Journal of Sports Sciences,* 21(7), 519-528.

Okada, T., Huxel, K.C. & Nesser, T.W. (2011). Relationship between core stability, functional movement, and performance. *Journal of Strength and Conditioning Research,* 25(1), 252-261.

Onate, J.A., Dewey, T., Kollock, R.O., Thomas, K.S., Van Lunen, BL., DeMaio, M. et al. (2011). Real-time intersession and interrater reliability of the functional movement screen. *Journal of Strength and Conditioning Research,* 26(2), 408-415.

Osgnach, C., Poser, S., Bernardini, R., Rinaldo, R. & Di Prampero, P.E. (2010). Energy cost and metabolic power in elite soccer: a new match analysis approach. *Medicine and Science in Sports and Exercise,* 42(1), 170-178

Padua, D.A., Marshall, S.W., Boling, M.C., Thigpen, C.A., Garrett, W.E. & Beutler, A.I. (2009). The landing error scoring system (LESS) is a valid and reliable clinical assessment tool of jump-landing biomechanics. *American Journal of Sports Medicine,* DOI: 10.1177/0363546509343200

Parchmann, C.J. & McBride, J.M. (2011). Relationship between functional movement screen and athletic performance. *The Journal of Strength and Conditioning Research,* 25(12), 3378-3384.

Peterson, C.L., Kautz, S.A. & Neptune, R.R. (2011). Braking and propulsive impulses increase with speed during accelerated and decelerated walking. *Gait Posture,* 33(4), 562-567.

Rahnama, N., Lees, A. & Bambaecichi. E. (2005). A comparison of muscle strength and flexibility between the preferred and non-preferred leg in English soccer players. *Ergonomics,* 48(11), 1568-1575.

Reilly, T. (1997). Energetics of high-intensity exercise (soccer) with particular reference to fatigue. *Journal of Sport Sciences,* 15, 257-263.

Reilly T. (2003). Motion analysis and physiological demands. In: Reilly T, Williams AM, editors. Science and soccer. London: Routledge, 59-72

Rienzi, E., Drust, B., Reilly, T., Carter, J.E.L. & Martin, A. (2000). Investigation of anthropometric and work-rate profiles of elite South American international soccer players. *Journal of Sports Medicine and Physical Fitness,* 40, 162-169.

Shultz, R., Mooney, K., Anderson, S., Marcello, B., Garza, D., Matheson, G.O. et al. (2011). Functional movement screen: inter-rater and subject reliability. *British Journal of Sports Medicine,* 45(4), 374.

Stolen, T., Chamari, K., Castagna, C. & Wisloff, U. (2005). Physiology of Soccer – An Update, . *Sports Medicine,* 35(6), 501-536.

Strudwick, T. & Reilly, T. (2001). Work-rate profiles of elite premier league football players. *Insight FA Coaches Association Journal,* 59, 1223-1230.

Strudwick, A., Reilly, T. & Duran, D. (2002). Anthropometric and fitness profiles of elite players in two football codes. *The Journal of Sports Medicine and Physical Fitness,* 42(2), 239-242.

Teyhen, D.S., Shaffer, S.W., Lorenson, C.L., Halfpap, J.P., Donofry, D.F., Walker, M.J., et al. (2012). The functional movement screen: a reliability study. *Journal of Orthopaedic & Sports Physical Therapy,* 42(6), 530-540.

Varley, M.C., Fairweather, I.H. & Aughey, R.J. (2012). Validity and reliability of GPS for measuring instantaneous velocity during acceleration, deceleration, and constant motion. *Journal of Sports Sciences,* 30(2), 121-127.

Waldron, M., Twist, C., Highton, J., Worsfold, P. & Daniels, M. (2011). Movement and physiological match demands of elite rugby league using portable global positioning systems. *Journal of Sports Sciences,* 11, 1223-1230.

Wisloff, U., Helgerud, J., & Hoff, J. (1998). Strength and endurance of elite soccer players. *Medicine and Science in Sports and Exercise,* 30(3), pp. 462-467.

8 – Appendices

Appendix A

Appendix B

Appendix C

VERBAL INSTRUCTIONS FOR THE FUNCTIONAL MOVEMENT SCREEN

FMS

The following is a script to use while administering the FMS. For consistency throughout all screens, this script should be used during each screen. The bold words represent what you should say to the client.

Please let me know if there is any pain while performing any of the following movements.

Deep Squat

Equipment needed: Dowel

Instructions

- **Stand tall with your feet approximately shoulder width apart and toes pointing forward.**
- **Grasp the dowel in both hands and place it horizontally on top of your head so your shoulders and elbows are at 90 degrees.**
- **Press the dowel so that it is directly above your head.**
- **While maintaining an upright torso, and keeping your heels and the dowel in position, descend as deep as possible.**
- **Hold the descended position for a count of one, then return to the starting position.**
- **Do you understand the instructions?**

Score the movement.
The client can perform the move up to three times total if necessary.
If a score of three is not achieved, repeat above instructions using the 2 x 6 under the client's heels.

Hurdle Step

Equipment needed: Dowel, Hurdle

Instructions

- **Stand tall with your feet together and toes touching the test kit.**
- **Grasp the dowel with both hands and place it behind your neck and across the shoulders.**
- **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.**
- **Touch the floor with the heel and return to the starting position while maintaining foot alignment with the ankle, knee and hip.**
- **Do you understand these instructions?**

Score the moving leg.
Repeat the test on the other side.
Repeat two times per side if necessary.

Inline Lunge

Equipment needed: Dowel, 2x6

Instructions

- **Place the dowel along the spine so it touches the back of your head, your upper back and the middle of the buttocks.**
- **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.**
- **Step onto the 2x6 with a flat right foot and your toe on the zero mark.**
- **The left heel should be placed at ______________mark.** *This is the tibial measurement marker.*
- **Both toes must be pointing forward, with feet flat.**
- **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.**
- **Return to the starting position.**
- **Do you understand these instructions?**

Score the movement.
Repeat the test on the other side.
Repeat two times per side if necessary.

Shoulder Mobility

Equipment needed: Measuring device

Instructions

- **Stand tall with your feet together and arms hanging comfortably.**
- **Make a fist so your fingers are around your thumbs.**
- **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.**
- **Do not "creep" your hands closer after their initial placement.**
- **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.

FMS

Active Scapular Stability (shoulder clearing)

Instructions

- **Stand tall with your feet together and arms hanging comfortably.**
- **Place your right palm on the front of your left shoulder.**
- **While maintaining palm placement, raise your right elbow as high as possible.**
- **Do you feel any pain?**

Repeat the test on the other side.

Active Straight-Leg Raise

Equipment needed: Dowel, measuring device, 2x6

Instructions

- **Lay flat with the back of your knees against the 2x6 with your toes pointing up.**
- **Place both arms next to your body with the palms facing up.**
- **Pull the toes of your right foot toward your shin.**
- **With the right leg remaining straight and the back of your left knee maintaining contact with the 2x6, raise your right foot as high as possible.**
- **Do you understand these instructions?**

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

Trunk Stability Pushup

Equipment needed: None

Instructions

- **Lie face down with your arms extended overhead and your hands shoulder width apart.**
- **Pull your thumbs down in line with the ___** (forehead for men, chin for women).
- **With your legs together, pull your toes toward the shins and lift your knees and elbows off the ground.**
- **While maintaining a rigid torso, push your body as one unit into a pushup position.**
- **Do you understand these instructions?**

Score the movement.
Repeat two times if necessary.
Repeat the instructions with appropriate hand placement if necessary.

Spinal Extension Clearing

Instructions

- **While lying on your stomach, place your hands, palms down, under your shoulders.**
- **With no lower body movement, press your chest off the surface as much as possible by straightening your elbows.**
- **Do you understand these instructions?**
- **Do you feel any pain?**

Rotary Stability

Equipment needed: 2 x 6

Instructions

- **Get on your hands and knees over the 2x6 so your hands are under your shoulders and your knees are under your hips.**
- **The thumbs, knees and toes must contact the sides of the 2x6, and the toes must be pulled toward the shins.**
- **At the same time, reach your right hand forward and right leg backward, like you are flying.**
- **Then without touching down, touch your right elbow to your right knee directly over the 2x6.**
- **Return to the extended position.**
- **Return to the start position.**
- **Do you understand these instructions?**

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

FMS

Spinal Flexion Clearing

Instructions

- **Get on all fours, and rock your hips toward your heels.**
- **Lower your chest to your knees, and reach your hands in front of your body as far as possible.**
- **Do you understand these instructions?**
- **Do you feel any pain?**

DEEP SQUAT

3

Upper torso is parallel with tibia or toward vertical | Femur below horizontal
Knees are aligned over feet | Dowel aligned over feet

2

Upper torso is parallel with tibia or toward vertical | Femur is below horizontal
Knees are aligned over feet | Dowel is aligned over feet | Heels are elevated

1

Tibia and upper torso are not parallel | Femur is not below horizontal
Knees are not aligned over feet | Lumbar flexion is noted

The athlete receives a score of zero if pain is associated with any portion of this test.
A medical professional should perform a thorough evaluation of the painful area.

Excerpted from the book, Movement: Functional Movement Systems—Screening, Assessment, Corrective Strategies

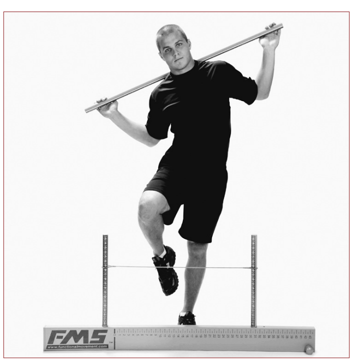
HURDLE STEP

3

Hips, knees and ankles remain aligned in the sagittal plane
Minimal to no movement is noted in lumbar spine | Dowel and hurdle remain parallel

2

Alignment is lost between hips, knees and ankles | Movement is noted in lumbar spine
Dowel and hurdle do not remain parallel



1

Contact between foot and hurdle occurs | Loss of balance is noted

The athlete receives a score of zero if pain is associated with any portion of this test.
A medical professional should perform a thorough evaluation of the painful area.

INLINE LUNGE

3

Dowel contacts maintained | Dowel remains vertical | No torso movement noted
Dowel and feet remain in sagittal plane | Knee touches board behind heel of front foot

2

Dowel contacts not maintained | Dowel does not remain vertical | Movement noted in torso
Dowel and feet do not remain in sagittal plane | Knee does not touch behind heel of front foot

1

Loss of balance is noted

The athlete receives a score of zero if pain is associated with any portion of this test.
A medical professional should perform a thorough evaluation of the painful area.

SHOULDER MOBILITY

3

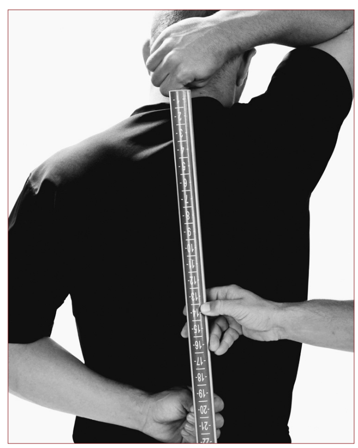
Fists are within one hand length

2

Fists are within one-and-a-half hand lengths

1

Fists are not within one and half hand lengths



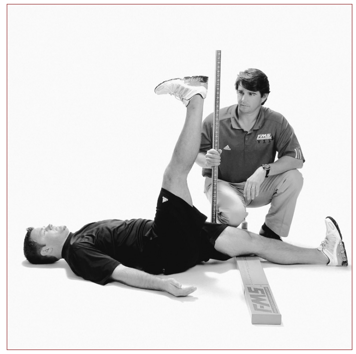
The athlete will receive a score of zero if pain is associated with any portion of this test.
A medical professional should perform a thorough evaluation of the painful area.

Clearing Test

Perform this clearing test bilaterally. If the individual does receive a positive score, document both scores for future reference. If there is pain associated with this movement, give a score of zero and perform a thorough evaluation of the shoulder or refer out.

ACTIVE STRAIGHT-LEG RAISE

3

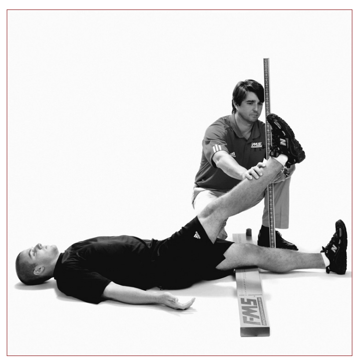


Vertical line of the malleolus resides between mid-thigh and ASIS
The non-moving limb remains in neutral position

2

Vertical line of the malleolus resides between mid-thigh and joint line
The non-moving limb remains in neutral position

1



Vertical line of the malleolus resides below joint line
The non-moving limb remains in neutral position

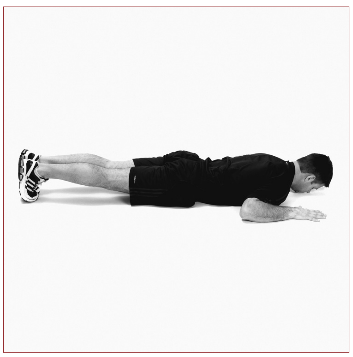
The athlete will receive a score of zero if pain is associated with any portion of this test.
A medical professional should perform a thorough evaluation of the painful area.

TRUNK STABILITY PUSHUP

3

The body lifts as a unit with no lag in the spine

Men perform a repetition with thumbs aligned with the top of the head
Women perform a repetition with thumbs aligned with the chin



2

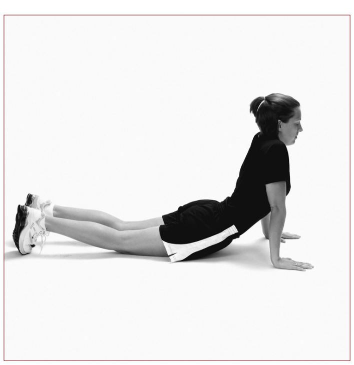
The body lifts as a unit with no lag in the spine
Men perform a repetition with thumbs aligned with the chin | Women with thumbs aligned with the clavicle

1

Men are unable to perform a repetition
with hands aligned with the chin

Women unable with thumbs aligned with the clavicle

The athlete receives a score of zero if pain is associated with any portion of this test.
A medical professional should perform a thorough evaluation of the painful area.



Spinal Extension Clearing Test

Spinal extension is cleared by performing a press-up in the pushup position. If there is pain associated with this motion, give a zero and perform a more thorough evaluation or refer out. If the individual does receive a positive score, document both scores for future reference.

ROTARY STABILITY

3

Performs a correct unilateral repetition

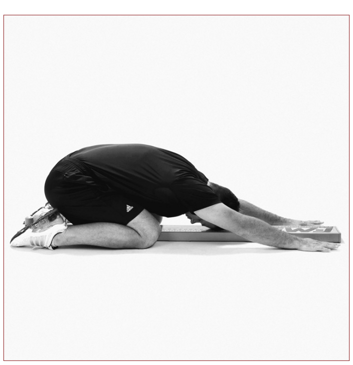
2

Performs a correct diagonal repetition

1

Inability to perform a diagonal repetition

The athlete receives a score of zero if pain is associated with any portion of this test. A medical professional should perform a thorough evaluation of the painful area.



Spinal Flexion Clearing Test

Spinal flexion can be cleared by first assuming a quadruped position, then rocking back and touching the buttocks to the heels and the chest to the thighs. The hands should remain in front of the body, reaching out as far as possible. If there is pain associated with this motion, give a zero and perform a more thorough evaluation or refer out. If the individual receives a positive score, document both scores for future reference.

FMS

The Functional Movement Screen

Scoring Sheet

NAME ____________________ DATE ____________ DOB ____________

ADDRESS ____________________

CITY, STATE, ZIP ____________________ PHONE ____________

SCHOOL/AFFILIATION ____________________

SSN ________ HEIGHT ________ WEIGHT ________ AGE ________ GENDER ________

PRIMARY SPORT ____________________ PRIMARY POSITION ____________________

HAND/LEG DOMINANCE ____________________ PREVIOUS TEST SCORE ____________________

TEST		RAW SCORE	FINAL SCORE	COMMENTS
DEEP SQUAT				
HURDLE STEP	L			
	R			
INLINE LUNGE	L			
	R			
SHOULDER MOBILITY	L			
	R			
IMPINGEMENT CLEARING TEST	L			
	R			
ACTIVE STRAIGHT-LEG RAISE	L			
	R			
TRUNK STABILITY PUSHUP				
PRESS-UP CLEARING TEST				
ROTARY STABILITY	L			
	R			
POSTERIOR ROCKING CLEARING TEST				
TOTAL				

Raw Score: This score is used to denote right and left side scoring. The right and left sides are scored in five of the seven tests and both are documented in this space.

Final Score: This score is used to denote the overall score for the test. The lowest score for the raw score (each side) is carried over to give a final score for the test. A person who scores a three on the right and a two on the left would receive a final score of two. The final score is then summarized and used as a total score.