Correlation between the Functional Movement Screen and Hip Mobility in NCAA Division II Athletes

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ABSTRACT

International Journal of Exercise Science 10(4): 541-549, 2017. The Functional Movement Screen (FMS) is a ranking and grading system used to subjectively analyze movements integral to normal function. It is used to identify functional limitations and asymmetries which limit the effectiveness of functional training and distort body awareness (1). The screening tests utilized by the FMS are the deep squat (DS), hurdle step (HS), inline lunge (IL), shoulder mobility (SM), active straight leg raise (ASL), pushup (PU), and rotary stability (RS), all of which comprise the composite score (FMS CS). The purpose of this study was to determine correlations between the FMS screens and hip mobility. The specific hip range-of-motion exercises used were bilateral internal/external rotation (IRR, IRL, ERL, ERR), and flexion/extension (FL, FR, ER, EL). Participants of both genders (32 males, 13 females) were solicited from four sports (baseball, softball, and men’s and women’s cross-country). The most significant/intriguing correlations were between FMS HS/FL, FMS ILL/R, FMS PU/FL, FMS ALL and IRR/L and ERR/L and FMS SM/ER. All correlations produced were weak to moderate at the .05 level of significance. These results demonstrate that hip range-of-motion plays a minor role in FMS score. Future studies should utilize a larger sample size, including more females, as well as analyze range-of-motion across multiple joints.

KEY WORDS: Flexibility, movement imbalance, injury in athletic populations

INTRODUCTION

The Functional Movement Screen (FMS) is the product of Gray Cook. The FMS is a ranking and grading system used to subjectively analyze movements integral to normal function. It is used to identify functional limitations and asymmetries which limit the effectiveness of functional training and distort body awareness (1). The screening tests utilized by the FMS are the deep squat, hurdle step, inline lunge, shoulder mobility, trunk stability pushup, active straight leg raise, and rotary stability (see figures below for photos of the FMS screens). The deep squat and hurdle step analyze mobility and functionality of the ankles, knees, and hips. The inline lunge, in addition to the above, also brings into account torso stability as well as
quadriceps flexibility. The shoulder mobility grades shoulder range-of-motion and capsular mobility. The active straight leg raise assesses hamstring and calf flexibility with a stable pelvis whereas the pushup analyzes symmetrical core stability. Rotary stability encompasses stability in the core with a component of upper and lower extremity mobility.

Each screen is graded on a scale of 0-3, with a 0 being given when pain is noted. A score of 1 was given when the movement could not be performed according to the established criteria; while a 2 is awarded when the movement is done with some minor compensations and deviations. A score of 3 was scored when the movement is completed according to established criteria (3).

Previous research has stated that lower FMS scores have often been connected with an increased injury risk in football players (8). However, Kiesel and colleagues also noted this correlation should not be used to establish any sort of cause and effect relationship between the FMS score and injury (8). When used as part of a pre-season screening, the FMS can be used to determine potential functional limitations that may place an individual at risk for
future injury (3). Cook et al. observed that lower FMS scores can be used as a predictor for injury (3). Although FMS scores do not establish a cause and effect relationship with injuries, they have been used as a tool to possibly forecast injury.

O’Connor et al. reported similar findings on their longitudinal study performed on officer candidates in the military (10). FMS was performed on candidates during pre-training medical screening and they were then divided into groups based off of length of training (short-course/6-weeks and long-course/10-weeks). They were then tracked throughout the course of training and injuries were noted and categorized as: overuse, traumatic, any injury (combination of overuse and traumatic), and serious injury. In the short-course group, candidates with an FMS score at or below 14 were observed to be 1.91 times more likely to incur an injury, while the long-course group was found to be 1.65 times more likely. It was found that FMS scores were not correlated to overuse injuries. O’Connor et al. concluded that FMS scores of 14 and below were found to have an increased injury rate; albeit with a low sensitivity (10).

Another study performed by Chimera et al. provided evidence to indicate that previous injury history as well as surgery were related to a lower score on the FMS (2). Athletes from various sports teams were included in the study, and when FMS composite score (CS) was analyzed in context of previous injury history, it was found that significant differences existed in reported composite scores. The hip injuries demonstrated the greatest difference: with a CS of 12.7±3.1 for those previously injured and 14.4±2.3 for those without a history of injury. The shoulder generated the next greatest gap at 13.5±2.6 for the previously injured group and 14.3±2.4 for the healthy group; followed by the knee at 13.9±2.3 for previous injuries and 14.4±2.5 for healthy individuals. The groups for the trunk and ankle reported similar CS consistent with the above data which is consistent with the notion that previous injury leads to a lower FMS CS (2).

Hip range-of-motion has also been implicated in athletic injuries. Verall et al. discovered this by analyzing the incidence of chronic groin injury in professional Australian football players (11). These players had no prior history of such groin injury in addition to possessing lower total measures of hip range of motion. Verall et al. found that restriction in hip range of motion precedes chronic groin injury and is a potential risk factor for the development of this injury (11). The restricted range of motion in the subjects would have led to dysfunctional movement patterns, which in turn would have been discovered by the FMS as it aids in identifying impaired movement patterns. This would have manifested itself in a lower FMS score.

Hammoud et al. performed a study that analyzed compensatory pain patterns in patients with mechanic hip pain (6). It was found that individuals with femeroacetabular impingement syndrome resulted in decreased hip range of motion which then caused compensatory injury and pain mechanisms (6). While the restricted hip range of motion was caused by an underlying condition, it is evident that even here it can cause pain syndromes and injuries such as hip flexor strain, iliopsoas impingement, and proximal hamstring syndrome, which
could be picked up in part by the FMS screens as they aid in identifying dysfunctional movement patterns which can precipitate injury.

Ibrahim et al. again confirmed that reduced hip range of motion precedes adductor strain in soccer players (7). Eight professional soccer players were followed from the preseason until the conclusion of the season who were noted to have reduced hip range of motion associated with adductor strains. The mean range of motion was significantly lower in the injured group as opposed to the healthy group (44.7º vs 53.7º). It was concluded from this study that reduction in hip range of motion can be considered a factor in adductor strains amongst elite soccer players (7). Hip mobility plays a key role in the functional movement of the hip joint. Many of the FMS movements test an individual’s hip range of motion which will directly affect their FMS composite scores.

The above data indicate that there is evidence that the FMS could be correlated to injury in athletic populations, and that hip range of motion is also connected to injury in athletes. It could be extrapolated from this data then that lower scores on the FMS would also be tied to lower hip range of motion values. Butler, et al. attempted to see if a connection existed between scores on the FMS deep squat and range of motion in several joints, including the hip, knee, and ankle (1). This study analyzed the score of 3 groups based upon a score of 1, 2, or 3. Scores of 0 were excluded from their analysis. Butler et al. reported figures for group 1 (FMS score of 1) as follows for dorsiflexion, knee flexion, and hip flexion, respectively; 24.5º ±2.3º, 84.7º ±4.3º, and 88.1º ±5.1º. Group 2 (FMS score of 2) was noted as: 27.9º ±2.6º, 110.0º ±4.9º, and 117.5º ±4.0º. Group 3 (FMS score of 3) had values of 31.4º ±1.8º, 130.7º ±3.8º, and 121.1º ±2.0º. These values indicate for the hip flexion groups 2 and 3 produced similar hip mechanics that ultimately led to a greater hip range of motion than the first group. The conclusion reached from this study was that improvements in joint mobility are incredibly likely to improve a deep squat score from a 1 to a 2 (1).

This data provides evidence to suspect a correlation between the FMS and hip range of motion. The researchers hypothesized that subjects with lower values for hip flexion, extension, internal rotation, and external rotation would have lower scores on the FMS screens as well as a lower FMS composite score. The purpose of this study was to determine the relationship between hip mobility and the Functional Movement Screen, which is necessary in order to give a clearer picture of how the FMS ties in with range of motion, specifically of the hip.

METHODS

Participants
All participants were NCAA division II student athletes at Lee University. Participants were purposefully sampled from teams that had not yet begun seasonal competition; participation was voluntary and was solicited by request to the coaches of the teams. Athletes not currently training due to injury or recovery from surgery were excluded. The sample size was composed of athletes from the baseball (22 subjects), softball (10 subjects), and men’s (10
subjects) and women’s (2 subjects) cross-country teams for a total sample size of 44 athletes. The average age, height, and weight of study participants are detailed in the table below.

Table 1. Average age, height, and weight of study participants.

| Sport         | Age (years) | Height (in.) | Weight (lbs.) |
|---------------|-------------|--------------|---------------|
| Baseball      | 20.0        | 72.1         | 190.2         |
| Softball      | 20.1        | 66.7         | 165.4         |
| Men’s XC      | 20.7        | 71.3         | 148.1         |
| Women’s XC    | 19.5        | 65.5         | 133.5         |

Protocol
Following IRB approval, subjects were given informed consent to complete, as well as a brief questionnaire asking about previous injuries and surgical interventions from the previous six months leading up to the study. The focus of the questionnaire was to determine if any foot, ankle, knee, hip, and shoulder injuries were present that would potentially impact range-of-motion or FMS score. If any injuries were indicated, then data was still collected the same as for all other participants. None of the subjects sampled were injured within two weeks of their data collection. Data collection occurred between August 2015 and January 2016.

All participants were measured on different days; as well at different times of day. Subjects scheduled appointments for data collection with the researchers. They were instructed to wear athletic clothing (shorts, tennis shoes, and a t-shirt). They were not instructed to warm up prior to measurement.

Flexion and extension of the hip, as well as internal and external rotation, were then collected using active range of motion with a goniometer on a standard examination table. Procedures were followed as per Norkin (9). Measurements were conducted by one of three researchers trained in goniometry. Researchers demonstrated ICC reliability of 0.970 in pilot testing prior to data collection. The participants were shown the exercises passively, and then instructed to perform them as far as they could actively without compensating on the opposite side or causing pain. The active movement was utilized for measurement.

Next, the Functional Movement Screen was conducted on participants. All three researchers performing the FMS had obtained prior FMS Level One Certification prior to data collection and had an ICC reliability of 0.905.

In lieu of standard FMS equipment the researchers utilized a 2x6 piece of lumber, with dowel rods purchased from a local hardware store. A piece of Theraband and two chairs were used for the hurdle step, and a standard tape measure was utilized to determine measurements for the hurdle step, lunge, and shoulder mobility.

The following FMS screens were performed and scored according to established criteria per Gray Cook: overhead deep squat, inline lunge, hurdle step, shoulder mobility, pushup, active straight leg raise, and rotary stability (4). Additionally, clearing tests were performed for the
pushup, shoulder mobility, and rotary stability to pick up any pain not found by the screens (4).

Statistical Analysis
The data was analyzed via SPSS v.20, utilizing a Spearman correlation for analysis. The alpha level used for significance was the 0.05, with some correlations being detected at the 0.01 level.

RESULTS

The tables below identify the correlations that were found to be significant at the .05 and .01 level. Table 2 provides the abbreviations used in this section. Table 3 shows correlations between Flexion Left/Right and FMS PU, DS, HSR, ILL/R. Table 4 lists notable correlations between Flexion Left, and Extension Left/Right with FMS ALL/R and RSL. Table 5 indicates correlations between Internal and External Rotation Left/Right with FMS SML/R and ALL/R. FMS scores can be seen in the supplemental figures. Bilateral exercises are separated by a (/).

| Variable                          | Abbreviation |
|-----------------------------------|--------------|
| Flexion Left/Right                | FL/R         |
| FMS Pushup                        | FMS PU       |
| FMS Deep Squat                    | FMS DS       |
| FMS Hurdle Step Left/Right        | FMS HSL/R    |
| FMS Inline Lunge Left/Right       | FMS ILL/R    |
| Extension Left/Right              | EL/R         |
| FMS Active Straight Leg Raise Left/Right | FMS ALL/R  |
| FMS Rotary Stability Left/Right   | FMS RSL/R    |
| External Rotation Left/Right      | ER L/R       |
| Internal Rotation Left/Right      | IR L/R       |
| FMS Shoulder Mobility Left/Right  | FMS SML/R    |

The * indicates significance at the 0.05 level. The † indicates significance at the 0.01 level.

DISCUSSION

The correlations produced were all weak to moderate. These were not as high as we expected. This is most likely due to the fact that the FMS screens are all multi-joint movements, and so one joint’s range of motion alone wouldn’t produce large correlations.

Most of the notable correlations are expected: that is, they make sense in light of the kinetic chain and the body parts involved. Take, for example, the FMS HSR and FL. This correlation is reasonable as the subject is required to utilize hip flexion to get the leg up and over the hurdle. The FMS IL L/R and FL is also similar: both movements require a certain degree of
flexion in the hip joint in order to perform the lunge movement. One must also employ flexion to a minor degree when doing the FMS pushup, as seen with FMS PU and FR.

Table 4. Correlations between the FMS ALL, ALR, and RSL with FL, EL, and ER.

| FMS/Hip ROM | ALL          | ALR          | RSL       |
|------------|--------------|--------------|-----------|
| FL         | _            | _            | .304*     |
| EL         | .427†        | .503†        | _         |
| ER         | .321*        | _            | _         |

The * indicates significance at the 0.05 level. The † indicates significance at the 0.01 level.

Table 5. Correlations between the FMS SML, SMR, ALL, and ALR with IRL, ERL, IRR, and ERR.

| FMS/Hip ROM | SML          | SMR          | ALL          | ALR          |
|------------|--------------|--------------|--------------|--------------|
| IRL        | _            | _            | .515†        | .507†        |
| ERL        | .480†        | .372*        | .484†        | .504†        |
| IRR        | .317*        | _            | .387*        | .399*        |
| ERR        | _            | _            | .361*        | .354*        |

The * indicates significance at the 0.05 level. The † indicates significance at the 0.01 level.

Slightly more perplexing is the correlation between the FMS AL L/R and all measures of hip internal/external rotation; at face value, one would not think rotation of the hip to be a primary driver of the straight leg raise. However, this could be explained by observing in practice that a subject’s hip will rotate to some degree in either direction when raising the leg. This could be explained by the actions of the sartorius muscle which is both a hip flexor and rotator, it is evident that the flexion needed to raise the leg off the ground would also be accompanied by some degree of rotation.

Also, it is notable that the correlations between the FMS AL L/R and hip mobility were the strongest correlations produced. This is because the FMS AL L/R is a one-joint exercise employing only the hip joint. However, this FMS screen did not correlate with hip flexion, and this is likely because the researchers employed a bent knee to measure hip flexion as opposed to the straight leg motion that is used with the FMS ALL/R.

The correlation that was most interesting was the FMS SM L/R and ERL. At first glance, it does not appear that one’s hip rotation could impact shoulder mobility. A previous study by Youssof, et al. has implicated hip range of motion with neuromuscular disorders (12), so it is plausible that there is some degree of nervous system control that ties together the hip and shoulder. Another, simpler explanation, employs the kinetic chain. The stability afforded by the hips in standing could cause spinal compensation, which would inhibit the ability to perform shoulder mobility. Different results might have been obtained had the participants performed this motion while seated, which could comprise an area for future study.

These results confirm the results of the Butler (1) study that found improvements in FMS DS score with increased hip range of motion. Although the correlations were only weak to moderate, it is evident from the results that hip range of motion can affect FMS scores; which is what was found by Butler and colleagues.
Previous work by Gomes, et al. has also implicated impacted hip range of motion with increased rates of injury, such as ACL injuries and chronic groin injuries (5). Hammoud also found that those with femeroacetabular impingement syndrome experienced decreased hip range of motion (6). Ibrahim again found that decreased hip range of motion preceded adductor strains in soccer players (7). Chimera’s work showed that hip injuries caused a decrease in FMS score (2). The dysfunctional movement caused by the injuries is what caused the lower FMS score, as the FMS was designed to pick up dysfunctional movement patterns and not as a predictor of injury. The pain from the hip injuries as picked up by the FMS would have led to a 0 score and therefore referral to advanced care.

This data ties into the research of Butler, O’Connor, Chimera, Kiesel, Verall, and Ibrahim because it has been seen that there are correlations between the FMS and hip range of motion (1,2, 7, 8, 10, 11). The decreased range of motion can play a role in terms of injuries; and the FMS is also correlated with increased injuries as noted by Kiesel, O’Connor, and Chimera (2, 8, 10). This work can bridge the two together by showing that this correlation between hip range of motion and FMS establishes an indirect link between the FMS and injuries, as range of motion is also implicated in injury. This can be used as a preventative tool: athletes with low FMS scores can also complete range of motion testing to determine which joint(s) have deficient motion, and then these can be corrected with exercises, flexibility stretching, and other modalities to increase FMS score which would also decrease rates of injury.

The primary limitations of the study were the small sample size. Also, future studies should employ a demographic composed of a more equal ratio of males to females, and include more athletes from different sports. Further work should also emphasize other joints, including the ankle, knee, and shoulder as these will play a role in the ability to perform the FMS screens. The role of side dominance in context of the FMS screens should also be analyzed. A topic of particular interest for future research is the noted correlation between the FMS SML and ERL.

In conclusion, the researchers found weak to moderate correlations between the FMS and hip range of motion, which supported the hypothesis that those with lower measures of hip flexion, extension, and internal and external rotation would also have lower FMS scores. The fact that positive correlations were produced indicates the data supports the hypothesis.

This study can be seen as a preliminary first step into further research into the FMS, joint range of motion, and possibly the influence of side dominance on the FMS screens. Future studies should assess broad range of motion across multiple joints in order to better produce a larger picture of how mobility plays into the FMS.

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