Differences in FMS Scores Among Distance Runners and Sprinters

Abstract

The role of exercise screening has become an integral part of athletic development leading to success in a variety of team and individual sports. There is sufficient evidence supporting the process of exercise screening for identifying potential limitations in muscular flexibility and joint range of motion (ROM) that can have a direct impact on the biomechanics involved in sport performance. Knowing the direct impact effective training modalities can have on musculoskeletal adaptations and overall performance in sport, more attention has been placed on the use of screening exercises such as the Functional Movement Screen (FMS). The FMS utilizes seven exercises involving common movement patterns that are likely to inhibit athletic performance and potentially lead to an increased risk of injury. These inhibiting factors can include a combination of muscular imbalances (i.e., weak muscles), lack of flexibility, and motor development concerns which can inhibit performance in many aspects of sport. The purpose of this study was to utilize the FMS to identify differences in movement patterns between distance runners, sprinters and jumpers involved in a collegiate track program. FMS scores for the distance runners (LD, n = 15) were compared with the sprinters and jumpers (SDJ, n = 15). An analysis between the two groups (n = 30) revealed a significant difference in overall FMS scores ($P < .001$) as well as three of the lower limb exercises (Deep Squat, $P = .040$; In-line Lunge, $P = .013$, & Hurdle Step, $P = .015$). The results indicate that the SDJ group showed better mobility while the LD group likely suffers from a lack of mobility in the trunk and lower limbs. The lack of mobility in the LD group is likely a result of repetitive movements that can lead to reductions in muscle flexibility and ROM at the joints. Further research is needed to explore the implications of these results and what impact this has on improving performance and reducing the risk of injury.

Keywords: Functional Movement Screen (FMS), range of motion (ROM), muscular flexibility, long distance (LD), short distance and jumpers (SDJ)

Introduction

Improving running economy is a key contributor for improving overall running performance in both short and long-distance runners. This is especially true for elite runners who are near their peak capacity for performance and rely on every aspect of training to squeeze the most out of their physiology (Daniels & Daniels, 1992; Saunders et al., 2004). Improving running economy at the elite level often comes down to very small improvements in performance, which can include improving movement quality as well as other physiological markers (Criab et al., 1996; Foster & Lucia, 2007). Therefore, a lot of attention has been placed on improving training outcomes by screening for movement quality for the purpose of correcting movement patterns that result in improved performance outcomes as well as identifying movement imbalances that could lead to injury (Barnes & Kilding, 2015; Hotta et al., 2015). It is also well understood that muscular flexibility and joint range of motion (ROM) can have a direct impact on joint function, which can also affect overall performance in running events due to the emphasis placed on form and quality of movement patterns to reduce drag and enhance forward motion (Hunter et al., 2011; Li et al., 2019).

There is some discrepancy over the effect of movement patterns on running economy and overall performance (de Oliveira et al., 2017; Mokha et al., 2016; Zhang et a., 2024). Knowing the impact training can have on muscular strength, endurance, and flexibility, more attention has been placed on the use of exercise screening tools to help identify common movement patterns that inhibit performance and potentially lead to injury (Barnes & Kilding, 2015; Mokha et al., 2016). It is important to note that many inhibiting patterns identified in screening protocols can be an indication of weak muscles, muscular imbalances, and/or poor flexibility, all of which can negatively impact performance and increase the risk of injury (Cook et al., 2013; Mohka et al., 2020). The use of movement screening tools, such as the Functional Movement Screen (FMS), can help identify these factors resulting in a potential reduction in movement inequalities and risk stratification (Beardsley & Contreras, 2014; Cook et al., 2013). The goal of this study was to utilize the FMS to identify trends in movement patterns and potential deficiencies between two different types of runners, collegiate distance runners versus sprinters and jumpers, to address concerns for improving movement economy and muscular flexibility as a precaution for preventing future injuries while also improving performance.

Movement economy is often referred to as an athlete's movement efficiency, which is measured by analyzing movement patterns that effect performance and sport outcomes (Saunders et al., 2004). Movement efficiency in running events can be the limiting factor or key contributor to winning, especially in the longer distances due to the impact of incorrect repetitive movement patterns adding up over time (Hansen et al., 2021). This had led to coaches focusing more attention on analyzing the biomechanics of their runners for the sake of improving performance. The FMS has been used to assess runners of varying levels of performance in recent studies (Agresta et al., 2014; Loudon et al., 2014). However, there is not a lot of evidence supporting the implementation of the FMS in collegiate distance runners and sprinters for the sake of assessing differences in movement efficiency, which is an area that needs to be addressed further (Waite, 2024). Some research has suggested there are no differences in FMS scores amongst runners competing in similar distances (de Oliveira et al., 2017; Loudon et al., 2014). Other evidence suggests that monitoring changes in FMS scores over the duration of a competitive season could indicate trends in performance, which is a potentially useful tool for coaches to utilize in training (Chapman et al., 2014). Therefore, the purpose of this study was to use the FMS as a tool for identifying differences in movement patterns between collegiate distance runners and sprinters

and jumpers, which can be used to identify concerns with muscular imbalances and flexibility that could lead to injury and decline in performance.

The reliability of the FMS has also come into question as it gained popularity amongst practitioners across many professions involving the assessment of movement and human performance. When using the FMS tool for assessing various athletic populations, multiple studies have shown support for both interrater and intra rater reliability suggesting the use of trained raters have a much lower variability in scores (Gribble et al., 2013; Minick et al., 2010; Onate et al., 2012; Smith et al., 2013). Repeated each testing protocols has also shown that interrater reliability is consistent in following the proper protocols and grading format used in the scoring process involved in the FMS (Elias, 2015; Shultz et al., 2013). The protocols for conducting the FMS require specific instructions that avoid the rater from providing cues for correcting movement and/or providing too much information. This is beneficial for supporting rater reliability, but it does not address the potential concern of participant knowledge of the FMS movements and the scoring process that could alter the screening process (Frost et a., 2013). Research has revealed that the FMS protocol is less effective in determining dysfunctional movement patterns when participants have prior knowledge of the correct movement patterns needed to execute each exercise properly (Frost et al., 2013). This supports the suggested protocols for conducting the screening exercises, which requires raters to avoid informing participants of correct movement execution beyond stating what position to start the exercise in prior to the screening protocol (Cook et al., 2013). Therefore, it is suggested to utilize two FMS certified raters when conducting the screening process. This process should include proper implementation of all FMS testing guidelines, thus supporting the reliability efforts of the data collection procedures discussed in recent research findings (Cook et al., 2011).

Utilization of two certified FMS raters during testing protocols is supported by research, which suggests there is an increase in reliability on scoring due to the ability to assess from two different views. This also allows for the raters to collaborate and review scores based on more than one angle of view (Teyhen et al., 2012). The research design utilized in this study involved two raters observing participants from two different angles, including frontal and sagittal planes of movement. The FMS protocols encourage raters to take the lowest score for each exercise, which is common practice when performing exercise assessments (Cook et al., 2013). The FMS testing guidelines providesclear instructions for raters to record the lowest score, leaving room for improvement for the participant and drawing attention towards the implementation of corrective exercises to improve movement patterns observed during the screening process (Cook et al., 2013; Shultz et al., 2013). Furthermore, research reveals that inter-rater reliability should involve steps to avoid bias including the unfamiliarity of participants involved in the study. This process helps to control the effect of inter-rater reliability due to the use of two non-bias raters collaborating on FMS scores for each participant (Minick et al., 2010). Intra-rater reliability should be addressed by ensuring each participant's knowledge of the FMS is assessed prior to participation (Gribble et al., 2013). Lack of participant knowledge and experience in FMS testing could helped to ensure that participants do not alter their performance based on prior knowledge of performing any of the seven exercises involved in the screening protocol (Gribble et al., 2011; Onate et al., 2012). Likewise, researchers should follow proper testing protocols for executing each exercise included in the FMS handout; this ensures that the raters do not "coach" athletes through the testing protocol (Beardsley & Contreras, 2014; Cook et al., 2011). These testing guidelines help to ensure that the outcomes of each movement are natural and not adjusted in order to to receive a higher score (Kraus et al., 2014).

Research Question

Is there a difference in FMS scores between long distance runners (LD) and short distance runners and jumpers (SDJ)?

Research Hypothesis

There will be a significant difference in FMS scores between long distance runners (LD) and short distance runners and jumpers (SDJ).

Null Hypothesis

There is no significant difference in FMS scores between long distance runners (LD) and short distance runners and jumpers (SDJ).

Research Design

The purpose of this study was to determine functional movement pattern differences between distance runners and sprinters/jumpers using the Functional Movement Screen (FMS). This study utilized a quantitative approach to examine the differences in functional movement patterns reported in long distance (LD) and short distance runners and jumpers (SDJ). Functional movement patterns were assessed using the Functional Movement Screen (FMS) to compare deficiencies in movement patterns between the two groups.

Independent Variables: (1) LD and (2) SDJ

Dependent Variable: FMS scores

The independent variables (IV) in this study included the two groups, the long-distance runners (LD) and the short distance runners and jumpers (SDJ). The dependent variable (DV) measured was the results from the FMS scores. The results of the FMS scores were compared between both groups using a Mann-Whitney U test. Follow up assessments were made to determine the significance between the lower limb exercises assessed within the FMS protocols.

Participants and Sample Selection

Participants recruited for this research study included both long and short distance running and jumping athletes aged 18-28 years from an NCAA DII collegiate track and field program. Participants were also selected based on ability to perform all seven FMS exercises (Cook et al., 1998). Inclusion criteria required all participants to be active members of the track and field program and free of any current musculoskeletal injuries. Upon being screened for injury and providing informed consent, participants were broken up into two separate categories, including long distance runners (LD) and short distance runners and jumpers (SDJ). Participants that were competing in running events 800m or further on the track were placed in the long distance (LD) running group. Participants competing in 400m or shorter, including sprinting and jumping events, were placed in the short distance and jumpers (SDJ) group. A total of 30 participants (N = 30) were involved in this study, including fifteen long distance runners (LD = 15) and fifteen short distance runners and jumpers (SDJ = 15). The LD group included seven female (n = 7) and eight male (n = 8) participants. The SDJ group included six female (n = 6) and nine male (n = 9) participants. No participants experienced injury during or immediately following the FMS testing protocols.

Instrumentation

The instrument used in this research study included the FMS Test Kit, whichwas used for the physical screening process to determine FMS scores in all participants. The FMS testing protocol involves a series of seven exercises performed in sequential order (Cook et al., 2011). The seven exercises include the following: Deep Squat, Hurdle Step, In-line Lunge, Shoulder

Mobility, Active Straight-Leg Raise, Trunk Stability Push-Up, and Rotary Stability. Following the guidelines of the FMS manual, participants were allowed to perform each of the seven exercises up to three attempts. This included performing two clearing tests, the Press-Up and Posterior Rocking test, which help to identify possible causes for lack of movement or joint impingement. Each exercise is scored on a scale of 0-3 points, with 0 representing pain during performance, 1 represents the inability to successfully execute the movement pattern, 2 reflecting some improper movement during the completion of the movement pattern, and 3 being a perfect score for executing the exercise correctly. Protocols for assessing individuals and assigning scores for each movement pattern using the FMS Test Kit can be found in the published FMS Home Study Course Manual (Cook et al., 2011).

The FMS Test Kit includes a 5-foot plastic board (2 x 6 feet), along with one 4-foot dowel, two 2-foot dowels, and an elastic red tube with loops on each end that are used for the Step Over exercise. This equipment is used for five of the seven functional movement exercises involved in the screening protocols, while the Shoulder Mobility only requires the use of the dowel for measuring distances between fists and Trunk Stability Push-Up requires no equipment to execute. The large dowel is used for many of the tests, including the Deep Squat, Hurdle Step, In-line Lunge, and Active Straight-Leg Raise. The plastic board is used for the Hurdle Step, Inline Lunge, Active Straight-Leg Raise, and Rotary Stability. The smaller dowels and the red rubber tube are only used for the Hurdle Step exercise. Instructions on the execution of each exercise and the proper application of equipment can be found in the FMS Manual (Cook et al., 2011).

Data Collection

Data collection involved the assessment of functional movement patterns using the FMS Kit. This sequential seven-exercise protocol was used to screen for deficiencies in movement patterns while performing common functional movements often utilized in sport and daily activities (Cook et al., 2013). Participants from both training groups were assessed once while wearing the preferred shoe for training (i.e., running shoes). The FMS scores were gathered using the FMS "Score Sheet" provided in the FMS Manual. Differences in FMS scores were compared between the LD and the SDJ groups.

Student research assistants were directly involved in the data collection process. The lead investigator (PI), a faculty member within the Department of Kinesiology at Fresno State University, helped train and grade initial FMS exercises alongside the student research assistants while data was gathered using FMS scoring sheets. The student researchers continued to gather the majority of data by following the FMS testing protocols on participants from both the LD and SDJ groups. All researchers involved in the testing protocols collaborated in discussing outcomes to ensure consistency was achieved within testing protocols. This collaboration of raters was aimed at ensuring FMS testing procedures met the recommended interrater and intrarater reliability standards (Elias, 2015; Gribble et al., 2013; Minick et al., 2013). All data was recorded using FMS scoring sheets and transferred into an Excel spreadsheet that was reviewed by the PI. Student research assistants took the lead on setting up the FMS equipment and organized testing schedules with all participants involved throughout the testing process.

Data Analysis

The data from this study was recorded in an Excel spreadsheet and analyzed using SPSS software. FMS scores were collected using the recommended execution of instrumentation and exercise assessment procedures. The FMS data was initially recorded by hand using an FMS

Score Sheet, which provided space for the researcher/rater to record height and weight of each participant, and score all seven of the exercises involved in the FMS protocol (Cook et al., 2011).

A Mann-Whitney U test was performed to determine if a significant relationship exists between the two groups based on recorded FMS scores (Thomas et al., 1999). According to the chi square table, the level of significant difference between the two groups tested was based on the value of difference between the overall FMS scores between the two groups in comparison to the critical value. The level of significance between the two measurements was established at $p < .05$. Mean values and standard deviations for the FMS were calculated and recorded separately for the LD and SDJ groups.

Results

The results revealed a significant difference between the LD and SDJ groups on overall FMS scores ($p < 0.001$), which supports the research hypothesis. The results also revealed that the SDJ group scored higher than the LD group in three of the four lower extremity movement patterns. There was a significant difference between the two groups based on the Deep Squat ($p = 0.040$), Hurdle Step ($P = 0.015$), and In-line Lunge ($P = 0.013$).

Table 1: Results from FMS Scores

Exercise Assessment	**LD Group $\underline{x}$ + SD**	**SDJ Group $\underline{x}$ + SD**	**Probability**
Deep Squat	1.8 ± 0.7	2.3 ± 0.5	$P = 0.040$
Hurdle Step	1.7 ± 0.5	2.1 ± 0.4	$P = 0.015$
In-line Lunge	2.0 ± 0.7	2.6 ± 0.5	$P = 0.013$
Active Straight-Leg Raise	2.1 ± 0.9	2.6 ± 0.6	$P = 0.064$
Total Score	14.3 ± 2.0	17.3 ± 1.2	$P < 0.001$

Table 1. Mean, probability, and standard deviation of the deep squat, hurdle step, in-line lunge, and straight-leg with the FMS total score between both groups of participants.

Table 1 reveals the results from all four of the lower extremity FMS exercises. The Deep Squat, Hurdle Step, and In-line Lunge exercises revealed a higher mean ($\underline{x}$) and lower standard deviation (SD) in the SDJ group than the LD group. For the Deep Squat LD = 1.8 ± 0.7 and SDJ = 2.3 ± 0.5 ($P = 0.040$); Hurdle Step revealed LD = 1.7 ± 0.5 and SDJ = 2.1 ± 0.4 ($P = 0.015$); In-Line Lunge revealed LD = 2.0 ± 0.7 and SDJ = 2.6 ± 0.5 ($P = 0.013$). There was no significant difference between the LD and SDJ groups in the Active Straight-Leg Raise ($P = .064$). The mean FMS scores out of a 21-point maximum revealed a level of significance between both groups ($P < 0.001$); LD = 14.3 ± 2.0 and SDJ = 17.3 ± 1.2. Upper extremity exercises were not included in Table 1 since the lower extremity exercises were determined to be the most applicable and transferable exercises relating to the biomechanical movement patterns in running and jumping activities.

Discussion

Among the seven fundamental movement exercises involved in the FMS, the SDJ group observed higher overall results suggesting greater mobility, stability, and neuromuscular coordination when compared to the LD group. Several studies give potential explanations as to why the sprinters and jumpers may have scored higher in the deep squat, in-lunge, and hurdle step-over exercises (Bushnell & Hunter, 2007). One possible reason for this outcome could be the addition of sport-specific resistance training that many sprinters and jumpers focus on more than distance runners (Naik et al., 2015). Participants involved in the SDJ group were required to lift three days a week during season, which involves training through movements similar to those presented in the FMS screening process (Parchmann & McBride, 2011). Sport-specific movements are used in the majority of athletics are designed to build strength, mobility, stability, and neuromuscular coordination, which increases athletic performance in competition (Lacour & Bourdin, 2015; Judges et al., 2003).

Previous research has revealed positive outcomes amongst higher achieving athletes suggesting sport-specific resistance training induces neural adaptations that improve motor skill development (Judges et al., 2003). These findings support the idea that neural adaptations increase motor unit synchronization, which further increases neuromuscular coordination underlying the technical aspect of skill performance. The more familiar an individual becomes with specific movement patterns, the greater they may be able to perform when replicating the movement (Judge et al., 2003). Knowing that the SDJ group regularly incorporated sport-specific resistance training into their weekly routines, this group would have had physiological and biomechanical advantages when replicating lower extremity movement patterns (Mann & Hagy, 1980; Mokha et al., 2022). Differences in scores between the LD and SDJ groups could indicate these benefits.

Likewise, differences in FMS scores could be attributed to biomechanical movement patterns that differentiate between the shorter and longer distance runners (Hansen et al., 2021). The primary goal of sprinting is to generate maximal velocity in a short amount of time (Bushnell & Hunter, 2007). To produce maximal speed, power and explosiveness are key factors. Proper sprinting form includes triple flexion of the lead leg (hip, knee, and ankle), in combination with triple extension of the back leg (hip, knee, and ankle plantar flexion). A high knee lift at a 90-degree angle is also utilized to help the runner cycle through each step and propel the runner in a forward direction towards the finish line (Bushnell & Hunter, 2007). The position of the body during a sprint requires greater flexibility in the hamstrings and mobility in the hips to keep the knee at a 90-degree angle (Bushnell & Hunter, 2007; Naik et al., 2015).

A study on hip flexion in distance runners and sprinters demonstrated that sprinters display approximately 10 –158 more flexion at the hip joint than distance runners (Mann & Hagy, 1980). Distance running, on the other hand, requires different biomechanical needs, such as a knee angle of 45-60 degrees, and tight Achilles and calf muscles for maximizing elastic energy storage and return (Criab et al., 1996; Daniels & Daniels, 1992). Previous research has revealed that inflexibility in certain areas of the musculoskeletal system may enhance running economy in sub-elite male runners by increasing the storage and return of elastic energy while minimizing the need for muscle-stabilizing activity (Criab et al., 1996). The differences in maximal and submaximal paces require different physiological responses from the body. In fact, research involving the comparison of same speeds on a treadmill between distance runners and sprinters found that even when distance runners attempted to sprint, there was still a 118-degree difference in the minimum hip angle (Bushnell & Hunter, 2007).

There is substantial evidence supporting the possibility that sport-specific training and performance adaptations could affect FMS screening outcomes. However, further research is necessary to understand the relationship between lower FMS scores in distance runners and its impact on performance. There is some support from research suggesting that the lack of flexibility in distance runners could be indicative of the repetitive nature of the sport and actually benefit performance (Criab et al., 1996; Li et al., 2019). Exploring the impact on decreases in flexibility and the positive increase greater elastic return, allowing runners to increase the overall running economy should be explored further. The relationship between muscle stiffness in distance runners and the associated movement patterns could suggest a shift in expectations for mobility screening outcomes for future assessments in this particular population of athletes.

Limitations

Limitations in this study include differences between training loads and routines between the LD and SDJ groups as well as the use of shoes worn during testing. As discussed above, the training loads and mode of training differentiate between both groups of participants, which may have a direct impact on mobility capacity and FMS outcomes. Likewise, shoe material varied between foam and carbon-based running shoes used by participants during the testing phases. Participants included 25 athletes with foam-based shoes and 5 with carbon-based shoes. The effect of shoe type on FMS scores is unclear, but differentiation in shoe wear should be identified in future studies involving these populations. Other limitations could include participant activity outside of testing periods relating to fatigue leading up to performance of the FMS testing protocols. There was no way to control participant activity levels, diet, recovery, or other lifestyle factors that may have influenced performance on testing days.

Conclusion

FMS scores from this study indicate that sprinters and jumpers scored significantly higher (p value) higher than distance runners overall, particularly in the lower extremity movement patterns. These results suggest that sprinters and jumpers may have greater mobility, stability, and neuromuscular coordination, and possibly less muscle stiffness, than distance runners. However, it is also important to disclose the differences in preparatory training. Sprinters and jumpers engage in training that involves sport-specific resistance exercises, resulting in largerresistance training volume that may correlate better with FMS exercise performance. Whereas, the distance group did not spend as much time performing these exercises, potentially putting these participants at a greater disadvantage in performing the lower extremity exercises involved in the FMS testing protocol. Sprinting, jumping, and distance running also require different physiological and biomechanical needs relative to daily training and performance demands. One focusses on maximal speed and power, while the other engages in sustained submaximal efforts for much longer periods of time. Differences between these athletes may indicate that lower FMS scores in the distance runners may actually be beneficial for their overall running economy.

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