ARE FUNCTIONAL MOVEMENT PATTERNS PRECURSORS TO FUNCTIONAL PERFORMANCE IN UNIVERSITY WOMEN'S SOCCER PLAYERS?

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Functional movement patterns (e.g., stepping, lunging) underlie higher-order skills (e.g., throwing, jumping). Thus, better jump performance may be associated with higher Functional Movement Screen (FMS) scores. We examined this relationship in 25 female university soccer players. Pearson Correlation was used to determine associations between FMS scores (out of 21) and CMJ height (cm), reactive strength (RSI-mod, m/s), and peak concentric, eccentric and landing forces (N/kg). FMS (14.68 ± 2.43) was moderately associated with jump height (23.78 ± 5.94 cm), $r(23)=0.54$, $p \leq 0.05$ and RSI-mod (0.22 ± 0.06 m/s), $r(23)=0.44$, $p \leq 0.05$. University women's soccer players who had higher FMS scores also jumped higher and had greater reactive strength. Ensuring functional movement pattern proficiency may enhance CMJ performance.

KEY WORDS: countermovement jump, soccer screening, Functional Movement Screen™

INTRODUCTION: Functional movement patterns such as squatting, reaching, stepping and lunging are multi-joint movements that are not sport specific, require simultaneous demands of motor control, mobility, strength and stability, and are considered foundational to higher-order performance skills such as jumping, throwing, and kicking (Cook, Burton, & Hoogenboom, 2006). The Functional Movement Screen™ (FMS) is a comprehensive screen used to identify limitations and asymmetries in seven fundamental patterns. The seven tests are the deep squat, hurdle step, inline lunge, shoulder mobility, active straight leg raise, trunk stability push-up and rotary stability. Poor outcomes on the FMS as represented by total scores of ≤ 14 out of 21 and/or the presence of asymmetries has been shown to increase the likelihood of athletic injury (Mokha, Sprague, & Gatens, 2016). Poor FMS outcomes may also negatively impact athletic performance. Previous researchers have documented components of the FMS to be moderately associated with agility T-test times in recreationally active participants (Okada, Huxel, & Nesser, 2011) and the deep squat as a differentiator of single leg jump performance but not speed or other jumps (Lockie et al., 2015) in reactional team sport participants. Parchmann and McBride (2011) reported no significant association between FMS scores and agility T-test times, jump height, 20-m sprint times or club head velocity in university golfers. They concluded the FMS was not an adequate field test for aspects of athletic performance. However, others found that elite track and field athletes with higher FMS scores had significant improvements in performance over a season indicating that proficiency in the 7 functional movement patterns was related to the ability to improve longitudinally (Chapman, Laymon, & Arnold, 2014). Thus, the notion that functional movement patterns, which are considered non-sport specific, are precursors to functional athletic performance measures remains debatable. Therefore, the purpose of this study was to examine the relationship between functional movement pattern proficiency and countermovement jump (CMJ) performance in a group of university female soccer players.
The CMJ was selected as it is commonly used assess athletic performance in soccer, and when performed on force plates provides more specific information about force production than simply jump height. We hypothesized higher FMS scores would be associated with higher CMJ height, peak concentric force, peak eccentric force, peak landing force, and indices of reactive strength.

METHODS: 25 healthy female soccer players (age, 20.1 ± 1.4, height, 166.9 ± 6.8 cm, mass, 63.3 ± 9.4 kg) from the same university team took part in this study. Participants underwent FMS and CMJ assessments as part of their pre-participation physical examination and testing was conducted by Level I FMS certified professionals, the lead and third authors plus two additional professionals. The study was approved by the University's Institutional Review Board.

Functional Movement Screen
The FMS is a comprehensive screen used to identify limitations and asymmetries in seven fundamental patterns. The seven tests are the deep squat, hurdle step, inline lunge, shoulder mobility, active straight leg raise, trunk stability push-up and rotary stability. The protocol for administering the FMS is fully described by Cook (2010). Each pattern is scored as a 0 (pain present), 1 (not completed as instructed), 2 (completed with compensation), or 3 (completed as instructed). No participants scored a 0 (pain present) for any of the seven FMS tests. Figure 1 shows assessing the hurdle step.

Countermovement Jump Assessment
After a warm-up that included sub-maximal effort CMJs, participants performed a bilateral (CMJ) on dual uniaxial force plates (ForceDecks, Vald Performance, Queensland, Australia) while holding a dowel across the posterior upper shoulders. See figure 2. They were all familiar with CMJ testing; they were instructed to bend the knees to 90 deg and “drop quick and jump high.” Any knee flexion while airborne resulted in a repeated test. ForceDecks software calculated the dependent variables of CMJ height (cm), reactive strength (RSI-mod, m/s), and peak concentric, eccentric and landing forces (N/kg). All data were recorded at a sampling rate of 1000 Hz. Three jumps were performed, and the jump with the maximal height was selected for analysis.

Figure 1. FMS testing.

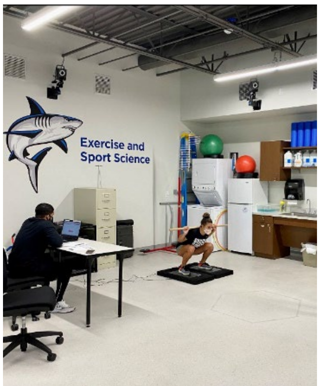

Figure 2. CMJ testing.

Data were transferred to a customized Excel file to extract the dependent variables. Statistics Package for Social Sciences (ver. 27; IBM Corporation, New York, NY, USA) was used for statistical analyses. Pearson’s correlation coefficients were calculated to determine associations between FMS scores (out of 21) and CMJ height, RSI-mod, and peak concentric, eccentric and landing forces. Statistical significance was determined as $p<.05$. Correlation strength was determined according to Hinkle, Wiersma, and Jurs (2003) and is as follows: 0.90 to 1.00 (-0.90 to -1.00) as very high, 0.70 to 0.89 (-0.70 to -0.89) as high, 0.50 to 0.69 (-0.50 to -0.69) as moderate, 0.30 to 0.49 (-0.30 to -0.49) as low, and 0.00 to 0.29 (0.00 to −0.29) as negligible.

RESULTS: Means and standard deviations of the dependent variables are shown in Table 1. Pairwise correlations between CMJ and FMS are shown in Table 2.

Table 1. Means and Standard Deviations of CMJ Results and FMS Scores (N=25).

Variable	Mean ± SD
FMS (out of 21)	14.68 ± 2.43
CMJ Height (cm)	23.78 ± 5.94
RSI-mod (m/s)	0.22 ± 0.06
Concentric Peak Force/BM (N/kg)	20.06 ± 1.21
Eccentric Peak Force/BM (N/kg)	17.25 ± 2.43
Landing Peak Force/BM (N/kg)	24.78 ± 7.14

Notes: BM denotes body mass, and RSI-mod denotes modified reactive strength index.

Table 2. Pairwise Correlations between CMJ Variables and FMS Scores (N=25).

Variable	FMS (out of 21)	CMJ Height (cm)	RSI mod (m/s)	Concentric Peak Force/BM (N/kg)	Eccentric Peak Force/BM (N/kg)	Landing Peak Force/BM (N/kg)
FMS (out of 21)	1.000					
CMJ Height (cm)	0.539*	1.000				
RSI-mod (m/s)	0.444*	0.875**	1.000			
Concentric Peak Force/BM (N/kg)	0.327	0.767**	0.774*	1.000		
Eccentric Peak Force/BM (N/kg)	0.105	0.375	0.527*	0.261	1.000	
Landing Peak Force/BM (N/kg)	0.157	0.390	0.317	0.288	-0.018	1.000

Notes: *Significant correlation, $p < 0.05$; **Significant correlation, $p < 0.001$; BM denotes body mass, and RSI-mod denotes modified reactive strength index.

Figures 3 and 4 display the statistically significant associations between CMJ height and FMS, and RSI-mod and FMS, respectively.

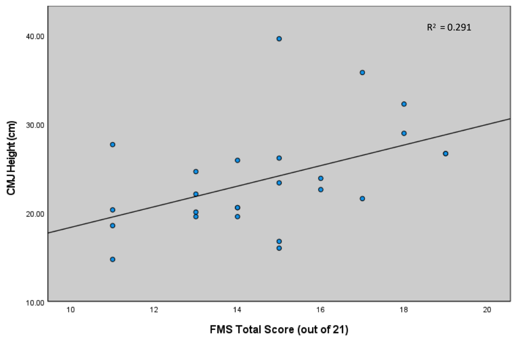

Figure 3. Relationship between FMS and CMJ height.

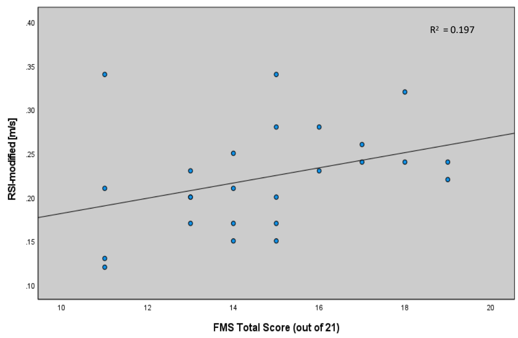

Figure 4. Relationship between FMS and RSI-mod.

DISCUSSION: The purpose of this study was to determine the influence of functional movement pattern proficiency on CMJ proficiency in university female soccer players. The CMJ was chosen because of its wide use in assessing athletic performance, or lower body power in soccer. The findings that participants with higher FMS scores jumped higher and had higher reactive strength indices are interesting and demonstrate that proficiency in whole body fundamental movement positively influences jumping ability. The ability to simultaneously coordinate balance, joint mobility and stability, and muscular strength are observed in both the FMS individual tests and a CMJ. The deep squat is especially similar biomechanically to the CMJ. We do observe that the R^2 values were low indicating the variability in jump height and RSI-mod are not well explained by the FMS scores. The findings that no CMJ peak forces during the concentric, eccentric and landing phases were related to FMS proficiency demonstrates that perhaps other force-time characteristics such as impulse and relative phase times (e.g., concentric:eccentric ratio) should be evaluated. It also plausible that simply being able to complete the functional pattern with proficiency does not mean that one can produce large vertical forces in that pattern. However, this notion is questionable giving the relationship between FMS and RSI-mod found in this study; showing that participants with better functional patterns exploited the stretch-shortening cycle better. The FMS may have a role in assessing the readiness for athletic performance as it provides information on how well the participant performs the precursor movement patterns for higher level athletic movements regardless of a relationship to force production.

CONCLUSIONS: Ensuring that athletes are proficient in the 7 functional movement patterns may translate to better CMJ performance. Participants with higher FMS scores jumped higher and utilized the stretch-shortening cycle better as indicated by higher reactive strength indices. However, this relationship was not noted in peak force production during the concentric, eccentric or landing phases of the CMJ. CMJ kinematics along with the kinetics during athlete evaluation may provide a richer analysis into any association between functional movement patterns and athletic performance.

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