



## FMS CORRECTIVE INTERVENTION IMPROVES FMS COMPOSITE SCORE AND 1-MILE RUN TIME, WITHOUT CONCURRENT CHANGE IN HIP EXTENSION STRENGTH, VERTICAL JUMP OR T-SHUTTLE RUN TIME, IN RECREATIONAL RUNNERS

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### ABSTRACT

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The purpose of this research was to examine the effect of an intervention designed to improve functional movement as determined by Functional Movement Screen™ (FMS) composite scores, one mile run time, standing isometric hip extension strength, agility T-Test time, and vertical jump in recreational runners (N=12, 7 males and 5 females; Mean Age = 49.08±15.87 yrs.; and mean weekly run volume = 15.96±21.21 miles), while normal running training load was maintained. We employed a two group (Control and Treatment) randomized experimental design. The treatment group (n=6) completed a 6 week intervention using the standard corrective methodology advocated by the FMS organization in combination with their normal run training, while the control group (n=6) continued their normal run training without additional intervention. We found a significant interaction between group and pre/post measure with a large effect sizes demonstrating improvement in the treatment group for the both the 1 mile run time (F = 5.45, p=0.042,  $\eta^2$ = 0.353) and the FMS composite score (F = 10.55, p=0.009,  $\eta^2$ = 0.513). There were no other significant interactions or meaningful effect sizes for any other dependent variable. This study supports the concept that a 6 week standard FMS intervention can result in concurrent improvements in both FMS composite score and 1 mile running performance without a concurrent change in running training load, isometric hip extension strength, vertical jump performance or t-shuttle times, in recreational runners.

**Contribution/Originality:** This study contributes in the existing literature by being the first to examine the effect of a corrective intervention for functional movement ability on both FMS score and athletic performance (1-mile run, t-shuttle, vertical jump, hip extension strength) concurrently, while simultaneously controlling for training, in recreational runners.

## 1. INTRODUCTION

Performance in distance running is influenced by a variety of factors including VO<sub>2</sub>max (Noakes *et al.*, 1990) lactate turn point (Farrell *et al.*, 1979; Noakes *et al.*, 1990) anaerobic muscle power (Paavolainen *et al.*, 1999) strength (Jung, 2003) running economy (Conley and Krahenbuhl, 1980) and training load (Foster, 1983). In addition, consistent injury free training is also widely considered to be essential to continued running performance improvements over time (Gabbett, 2016). Injuries can create considerable cost and have residual effects on loss of time in practice, competition, and increased risk for re-injury (Petersen and Hölmich, 2005; Yu *et al.*, 2008; Lorenz and Reiman, 2011).

The role of movement ability, as assessed by the Functional Movement Screen™ (FMS), in running performance is unclear. The FMS is a systematic assessment used to measure factors which are integral to the performance of sport-related skills including muscular strength, flexibility, endurance, coordination, balance, and movement efficiency (Cook, 2001). A criterion score of 14 or below on the FMS has been demonstrated to identify American professional football players (Kiesel *et al.*, 2007) female collegiate athletes (O'Connor *et al.*, 2011) and Marine officer candidates in training (Chorba *et al.*, 2010) who have a higher than normal potential risk for injury.

However, studies examining relationships between FMS scores and athletic performance tests have found either weak or non-significant relationships (Okada *et al.*, 2011; Parchmann and McBride, 2011; Lockie *et al.*, 2015) implying that movement ability may have little or no effect on athletic performance. However, these studies did not include training interventions for the purposes of improving functional movement ability or performance. By contrast, Chapman *et al.* (2014) demonstrated that collegiate track and field athletes who begin collegiate programs with low FMS scores experience less performance improvement than athletes who have higher initial FMS scores (Chapman *et al.*, 2014) suggesting that movement ability may affect improvements in running athletic performance.

The FMS has mixed results in regards to improving functional movement ability using interventions. Frost *et al.* (2012) used pre and post FMS scores to evaluate the effectiveness of training interventions for firefighters and found no significant differences (Frost *et al.*, 2012). By contrast, Kiesel *et al.* (2011) demonstrated an improvement in FMS scores following an off-season intervention program in American football players (Kiesel *et al.*, 2011) and Bodden *et al.* (2015) found the similar results following a four week intervention in mixed martial artists (Bodden *et al.*, 2015). O'Connor *et al.* (2011) also found that FMS scores not only predicted injury in a group of Marine office candidates during training, but also showed that a significantly lower percentage of individuals with high fitness scores came from the low FMS scoring group (O'Connor *et al.*, 2011). McGill *et al.* (2012) observed movement quality, performance and injury rates among a collegiate level men's basketball team for two years. This study used the FMS as a means of assessing movement quality, but also used an additional 13 movements along with speed, agility and strength tests used by the National Basketball Association. There was no training intervention and the results of the study only found a significant relationship between performance and improved mobility, with no significant relationship to FMS scores (McGill *et al.*, 2012). None of the currently published studies evaluate the use of a specific intervention designed to improve FMS scores while simultaneously measuring the effect of the intervention on athletic performance and controlling for other established confounding factors.

Our study examined the relationship between FMS scores and athletic performance in a typically low functionality group, recreational distance runners (Agresta *et al.*, 2014) as well as introduced a training intervention specifically designed to improve mobility and functional movement. The purpose of the study was to determine if an intervention designed to improve functional movement patterns, would also result in improved FMS scores and athletic performance measures.

## 2. METHODS

### 2.1. Subjects

Our mixed gender sample consisted of 5 females and 7 males, with the first 6 subjects to consent to participate assigned to the treatment group (n=6; F=2, M= 4) and the final 7 subjects to consent to participate assigned to the control group (n=7; F=3, M=4). The data from one member of the control group was removed from the analysis due to a failure to meet the requirements for participation previously outlined during the course of the study. This resulted in a final n of 6 (F=3, M=3) in the control group. The sequential assignment approach to randomization was necessitated by instructor and training facility availability over the three academic semesters during which the project was conducted. Sample group descriptors by gender can be found in Table 1.

**Table-1. Subject Descriptives by Gender (M±SD)**

Gender	Age (years)	Weekly Running Volume (miles)	Mile Time (min/secs)
Male	52.71±14.11	18.79±14.24	7:09.52 ± 0:40.61
Female	44.00±18.41	12.00±8.51	8:52.24 ± 1:27.55

Participants were risk classified using ACSM Health Screening criteria and required to have medical clearance prior to being accepted for participation when so indicated by the criteria (Pescatello *et al.*, 2014). Inclusion criteria included the following: 1) to be an adult actively training for running and/or triathlon competition; 2) to agree to continue current run training without further progression throughout the study and return training logs upon completion; 3) to not initiate any form of additional weight training beyond that being completed currently; and 4) to not be currently engaged in any form of functional training for the purpose of rehabilitation or otherwise. Potential participants were excluded if they were not able to obtain medical clearance following screening, had an existing musculoskeletal injury or scored a zero on any of the FMS individual test items upon initial testing. This study was approved by the Colorado State University – Pueblo Institutional Review Board.

### 2.2. Testing

Subjects completed pre-testing in two sequential sessions. The FMS assessment was conducted and videotaped in session one, while athletic performance measures were completed in session two in the following order: 1) vertical jump, 2) Agility T Test, 3) standing isometric hip extension, 4) 1-mile run. Vertical jump performance was assessed using a vertical jump trainer (Tandom Sport, Louisville, Kentucky, USA). The Agility T Test was conducted indoors on a wood floor using procedures described by Top end Sports (Wood, 2010). Standing hip extension strength was measured using a standing hip-leg-back dynamometer (Lafayette Instruments, Lafayette, Indiana, USA). The 1-mile run test was performed on an indoor running track (12.75 laps per mile) and hand timed. Heart rate was measured during the run using a heart rate monitor (Polar FT1, Polar Electro Inc., Lake Success, NY, USA) which calculated both mean and peak heart rate during each mile running trial. Following the intervention period, post testing was conducted using the same procedures and apparatus in the same order and at the same time of day.

### 2.3. Intervention

Subjects assigned to the control group continued their normal running training over the six-week training period without further intervention. Subjects assigned to the treatment group completed an FMS corrective intervention designed to improve functional movement ability (Cook *et al.*, 2011) and were led in small groups of 2-3 by undergraduate students who were trained in the process. This involved a standard progression of mobility to stability to integration exercises, as advocated by the FMS organization (Cook *et al.*, 2011) with a primary focus on specific movement deficiencies as identified through pre-testing.

### 2.4. Data Analysis

FMS composite scores were treated as a continuous variable with individual movement scores on the screen treated as categorical variables for the purposes of data analysis. Means (M) and standard deviations (SD) for age, weekly running mileage and mile run time were calculated and presented both in aggregate and by gender as descriptive data. Means (M) and Standard Errors (SE) were calculated from the intervention for each of the dependent variables by condition and time and are presented in Table 2. The data were analyzed using Statistical Package for Social Sciences (SPSS), version 19.

**Table-2. Participant FMS Scoring by Gender**

	FMS (M±SD)	Squat (Mode)	Hurdle (Mode)	Lunge (Mode)	Shoulder (Mode)	Leg Raise (Mode)	Pushup (Mode)	Rotary (Mode)
Male (n=7)	11.86±2.41	1	2	2	1	1	2	2
Female (n=5)	12.6±2.30	2	2	2	3	2	1	1

Pearson correlation was used to analyze the relationships between the FMS composite scores and each other dependent measure across all subjects and test sessions (N=24). The alpha level was set at  $p \leq 0.05$ .

The effect of the intervention on the dependent variables was analyzed using separate mixed 2 x 2 ANOVAs for each variable. The partial eta squared ( $N_p^2$ ) value for each ANOVA was calculated as a measure of effect size and interpreted using the following categories: 0.01 (small), 0.09 (medium) and 0.25 (large).

### 3. RESULTS

Mean and standard deviation scores for the FMS composite test and mode scores for the individual test items by gender from the pre-test may be found in Table 2.

The mean and standard error scores for all the dependent variables in control and treatment conditions before and after the intervention period can be found in Table 3.

**Table-3. Dependent Variables Pre and Post by Control versus Treatment Group**

Variables	Control		Treatment		p	$N_p^2$
	Pre (M±SE)	Post (M±SE)	Pre (M±SE)	Post (M±SE)		
FMS (composite score)	12.66±1.11	12.83±1.24	11.67±0.76	14.67±0.88	0.009 *	0.53***
Mile Time (min/secs)	7:40.8±0.80	7:43.6±09.5	8:03±43.5	7:37.0±39.9	0.042*	0.32***
Mile avg. heart rate (bpm)	159.5±4.70	155.6±4.32	165.33±3.94	161.33±5.86	0.974	0.000
Mile peak heart rate (bpm)	170.4±7.27	167.4±3.47	176.5±6.67	173.83±7.18	0.947	0.000
Vertical Jump (inches)	15.16±1.72	14.83±1.44	16.83±1.83	17.16±1.76	0.461	0.056
Agility -T-test (secs)	15.23±1.23	15.20±1.06	14.54±1.29	14.29±1.22	0.69	0.017
Hip Extension (lbs)	247.50±55.91	242.5±53.56	203.00±33.0	202.5±22.44	0.73	0.014

Note: \*p < 0.05, \*\*  $N_p^2$  moderate, \*\*\*  $N_p^2$  large

A significant moderate correlation was found between FMS score and vertical jump ( $r = 0.48$ ,  $p = 0.017$ ). There was no significant relationships between FMS score and leg press strength, mile run time or leg press.

There was a significant interaction between time (pre and post) and condition (intervention versus control) for both FMS composite score ( $F = 10.55$ ,  $p=0.009$ ,  $N_p^2 = 0.513$ ) and 1-mile run time ( $F = 5.45$ ,  $p=0.042$ ,  $N_p^2 = 0.353$ ) demonstrating a statistically significant improvement for each variable in the treatment group with a strong effect size. These interactions are illustrated in Figure 1 and 2 respectively.

### Effect of FMS Intervention on FMS Scores

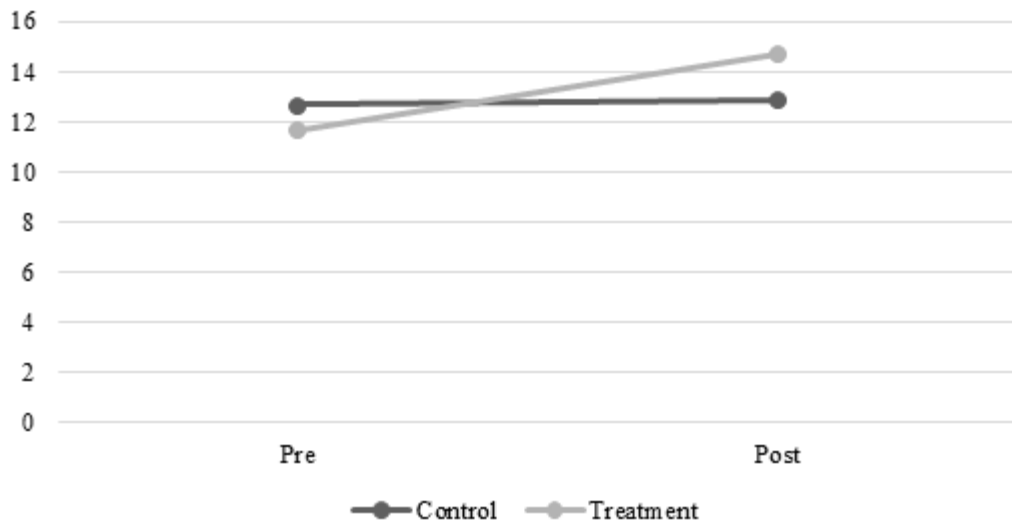


Figure-1. Comparison of FMS Intervention between Treatment and Control Groups on FMS composite scores

### Effect of FMS Intervention on Mile Run Times

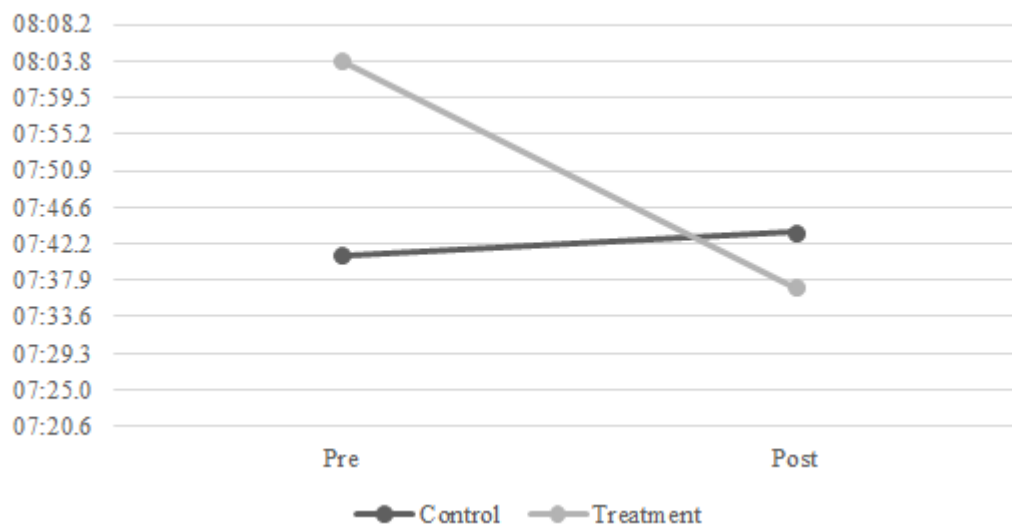


Figure-2. Comparison of FMS Intervention between Treatment and Control Groups on 1-Mile Run Times

There were no significant interactions between time (pre and post) and condition (intervention versus control) for leg press strength, t- shuttle run time, vertical jump, mean heart rate or peak heart rate during the 1-mile runs.

#### 4. DISCUSSION

This study demonstrates a significant effect of the FMS corrective intervention on FMS composite scores and 1 mile run time, without an effect on leg press strength, vertical jump or t- shuttle run time, with run training load held constant. This finding strongly suggests that improving movement ability in recreational runners, as measured by the FMS, causes improvement in distance running performance without a concurrent increase in strength, power or training load. Because the improved running performance in the treatment group was also not associated with a simultaneous increase in either average or peak heart rate, it can be speculated that the improvement may have occurred through a change in running efficiency and/or economy, although this study cannot confirm that observation.

Our experimental findings appear to be in contrast with some of the available studies which have examined the relationship between FMS scores and athletic performance measures and found either weak or non-significant relationships (Okada *et al.*, 2011; Parchmann and McBride, 2011; Lockie *et al.*, 2015) leading Kraus et al. in their review of the FMS research to conclude that very little evidence exists suggesting that movement ability has a relationship with athletic performance (Kraus *et al.*, 2014). However, while we also found no significant relationships between several of our chosen athletic performance measures and FMS scores, vertical jump was an exception showing a significant positive relationship. These findings suggest that movement ability, as measured by the FMS, may have little role in determining the variability between individuals in high power output running and jumping performances. However, because our sample had a low initial mean FMS scores which subsequently improved beyond the widely used 14 point cut-off point for increased risk of injury threshold in the treatment group, it may also be theorized that movement ability acts as a limiter on middle distance running performance in a given individual, most notably when it is below some critical threshold level. Our study further supports the concept demonstrated by previous researchers that FMS interventions can reasonably be expected to result in changes in both FMS scores (Kiesel *et al.*, 2011; Bodden *et al.*, 2015) and related outcomes such as injury rate (Allen *et al.*, 2013).

In addition, the large effect size associated with the middle distance running performance improvement in this study, combined with our somewhat heterogeneous sample of adult recreational runners, suggests that this form of intervention may be of meaningful benefit to a wide range of recreational runners, particularly if they currently demonstrate low FMS scores.

The findings of this study should be considered as preliminary, due to several methodological limitations in research design. The participants were not blinded as to study group as we considered that any form of meaningful sham treatment was likely to influence one or more of the dependent variables. However, our heart rate data suggests that the subjects performed at comparable efforts in their pre and post running trials, negating the concern for treatment group bias typically present when subject blinding is not possible. In addition, the difficulty in recruiting subjects resulted in a small mixed gender sample with low power.

The primary implication of this study is support for additional interventional studies examining the role of movement ability as a potential limiter to individual athletic performance in running.

In conclusion, this study demonstrates that a 6-week FMS corrective intervention results in improved FMS scores and 1-mile running performance, without concurrent improvement in vertical jump, hip extension strength or agility t-test run times, in recreational runners with low initial FMS scores.

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**Competing Interests:** The authors declare that there are no conflicts of interests regarding the publication of this paper.

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