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Functional movement test scores improve following a standardized off-season intervention program in professional football players

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The purpose of this study was to determine if an off-season intervention program was effective in improving Functional Movement Screen™ (FMS) scores in professional American football players. Pre- and post-intervention FMS scores were obtained on 62 subjects who completed a 7-week off-season intervention program. A repeated measures ANOVA was conducted to determine the effectiveness of the training program on FMS scores. A chi-square was performed to determine if there were a greater number of players who met the injury threshold and if asymmetries were reduced following intervention. Logistic regression was used to predict what factors were associated with failure (post-test score of <14). There was a positive main effect for time ($P<0.01$) and a greater number of individuals with a score >14 following the intervention. At post-test, 41 players were free of asymmetry as compared with 31 at the pre-test. The strongest predictor of program failure was a low squat score at pre-test. This study demonstrated that fundamental movement characteristics do change with a standardized intervention. Further research is required to determine if injury risk is reduced when a player's score improves beyond the established cut-off of 14 and/or asymmetry is resolved.

There are limited published reports on injury risk factors for professional American football players (Powell, 1987). The most prominent risk factor identified in prospective injury risk studies in athletics is previous injury (Turbeville et al., 2003; Tyler et al., 2006). Previous injury is a complex risk factor implying that something fundamentally changes following injury. It is possible that following injury there is a fundamental change in motor control that is not measurable with a single traditional impairment measurement such as strength or range of motion. In an attempt to capture the complex construct of motor control, movement oriented tests that assess functional movement and dynamic balance have been developed (Cook et al., 2006; Plisky et al., 2006). Tasks requiring coordinated full body movements may, in part, help us understand what fundamentally changes following injury. One test that has been established to assess neuromuscular impairments with movement is the Functional Movement Screen™ (FMS).

The FMS is a test of seven fundamental movements that has previously been determined to be able to predict injury in professional football players. Previous research has shown that players scoring lower than a 14 on the FMS were more likely to be injured than those scoring above 14 (Kiesel et al., 2007). A follow-up study to this initial investigation, validated the previous finding and in addition observed that players with any asymmetry on the FMS, regardless of total score, had 2.3 × greater risk for injury (Kiesel et al., 2008). While it appears the FMS may be beneficial in injury prediction, no studies have assessed whether changes in an individual's FMS score can be achieved with a training program.

As a result of the aforementioned literature, the purpose of this study was to determine if an off-season intervention program is effective in improving FMS scores in professional American football players. In addition, this study wanted to examine if there was a greater percentage of players above the injury threshold of a score of 14 at the end of the study compared with the beginning of the study. Because right and left asymmetry in the FMS has also been related to injury, we also examined if more players were free of asymmetry at the end of the study compared with the beginning of the study. Finally, we wanted to determine if it was possible to predict who would not improve their score above the injury threshold score using data from the pre-screen.

Methods

This study was completed on a sample of 62 healthy American football players from one professional team who participated in a structured off-season strength and conditioning program. In addition to traditional strength and conditioning components, the program also included an individualized intervention program which was prescribed based on the individual's score on the FMS™ as described by Cook (2001).

FMS

The FMS is a comprehensive screen that assesses quality of fundamental movement patterns to identify an individual's limitations or asymmetries (Cook et al., 2006). The FMS includes seven tests which are scored on a 0–3 ordinal scale. The seven tests of the FMS are the squat, hurdle step, lunge, shoulder mobility, active straight leg raise, push up and rotary stability. A score of 3 indicates the movement was completed as instructed and is free of compensation and pain. A score of 2 indicates the subject could complete the movement pain-free but with some level of compensation, while a score of 1 indicates the subject could not complete the movement as instructed. A score of 0 is assigned if the subject experiences pain with any portion of the movement. The reliability of the FMS has been established in a recent study (Minick et al., 2009) which reported weighted kappa values to range from 0.80 to 1.00.

Of the seven tests that comprise the FMS, five of them (hurdle step, lunge, shoulder mobility, active straight leg raise and rotary stability) are performed and scored separately for the right and left sides of the body. Because of the established relationship between neuromuscular asymmetry (right vs left differences) and injury risk, it is common practice to track right vs left sided differences on the FMS. Asymmetry is dichotomized for research purposes and if an asymmetry exists in an individual's score it is prioritized in the corrective program in an attempt to achieve the goal of symmetrical movement on all five of the right/left FMS tests.

Off-season training program

After initial FMS scores were obtained, subjects were prescribed an individual training program, based on their FMS score, designed to correct the identified movement deficits. This program consisted of a "movement preparation" component that included self and partner stretching and self-administered trigger point treatment done using The Stick (The Stick/RPI Atlanta, Georgia, USA) of major muscle groups thought to be contributing to the dysfunctional movement patterns. Individual "corrective exercises" were also prescribed and performed with the supervision and instruction of the strength and conditioning staff as needed. The corrective exercises are intended to utilize the range of motion gained from the stretching and allow for motor learning to occur as the subject moves through previously limited patterns of movement. Additionally, the corrective exercises are designed to stimulate natural core muscle activation to enhance the relationship between core muscle function and fundamental movement (Cook & Fields, 1997).

The goal was for the subjects to become independent with performing both components of the program. The exercises were progressed in a standardized manner with the goal of achieving the best possible movement strategy related to each of the seven movements tested. The program also included traditional strength and conditioning activities. See Table 1 for an example of an individual intervention program utilized in this study that incorporates movement preparation and corrective exercise as defined.

Athletes were required to participate in the 7-week program which included supervised sessions 4 days/week and two optional sessions per week. The program followed a structured progression with the goal of completing the final phase of corrective exercises as part of the routine strength and conditioning program. Post-test FMS scores were obtained at the completion of the program.

Statistical analysis

For the purposes of analysis, the subjects were grouped by position with lineman and linebackers (lineman, $n = 32$) in one group and all others position players in another group (non-lineman, $n = 30$). Mean and standard deviations for the pre-test and post-test FMS scores were calculated for each group. To determine if there was a change in FMS scores following the intervention period, a repeated measures ANOVA with the significance level set at $P < 0.05$ was conducted with the repeated measure being time (pre-test and post-test scores) and the between subjects variable being group (lineman and non-lineman). A one-way chi-square was performed to determine if there was a significant increase in the number of players scoring above the injury threshold score of 14 following the program. A similar analysis was performed to determine if there was an increase in the number of players that were free from asymmetry at the end of the program. For the chi-square analysis, the expected distribution utilized for the analysis was the distribution that was obtained at baseline. Finally, a logistic regression was utilized, using the variables position, asymmetry present and baseline score on the deep squat in order to predict which individuals did not improve their score to above the injury score threshold at the end of the program. Further rationale for the selection of these variables is highlighted in the discussion section of the manuscript.

Results

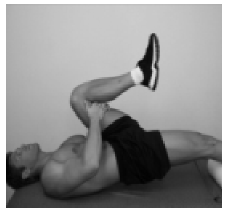
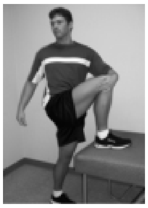
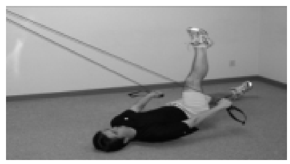
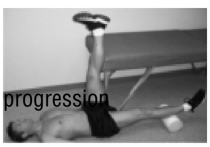
There was no time by position interaction for the FMS scores over the course of the training program (Fig. 1, $F = 0.08$, $P = 0.78$), however there was a main effect of time (Fig. 1, $F = 180.4$, $P < 0.01$). The mean pre-test score for the lineman was 11.8 (SD 1.8) and for the non-lineman group was 13.3 (SD 1.9). The mean post-test score for the lineman was 14.8 (SD 2.4) and for the non-lineman group was 16.3 (SD 2.4). Combined data for all subjects for the pre-test and post-test for each component of the FMS are presented in Fig. 2.

At the end of the intervention, a greater number of players exhibited a score that improved to above the injury threshold compared with before the intervention ($\chi^2 = 164.9$, $P < 0.01$). Thirty-nine subjects exhibited a score that exceeded the injury risk threshold at the end of the program compared with seven that exhibited a score >14 at baseline (Table 2).

In regards to the changes in symmetry scores, a greater percentage of players were free from asymmetry at the end of the study as compared with the beginning of the study ($\chi^2 = 7.8$, $P = 0.01$). Following the intervention, 42 players were free of asymmetry compared with the 31 players that demonstrated at least one asymmetry at baseline (Table 2).

The results of the logistic regression suggest that failure to improve above the injury threshold score of 14 can be predicted by a low deep squat score during the initial data collection. Neither position nor the presence of asymmetry was a significant predictor of whether or not the players score was able to be improved above the score of 14.

Table 1. Example of an individual off-season intervention program based on pre-test Functional Movement Screen™ score

Test	Score	Final	Movement prep	Corrective exercise
Deep squat	2	2		
Hurdle step	R-2 L-3	2	 Anterior thigh stick work	 Straight leg bridge
			 Stride Self-Stretch	 Single leg stance with core engagement
In-line lunge	R-2 L-2	2		
Shoulder mobility	R-3 L-3	3		
Active straight leg raise	R-1 L-2	1	Anterior thigh Stick work (see above)	
			 Straight leg partner stretch	 Leg lowering with core engagement
			 Leg lowering progression	 Single-leg toe touch w/stick
Trunk stability push-up	3	3		
Rotary stability	R-2 L-2	2		
Composite		15		
Asymmetry?		Yes		

Discussion

There is currently no evidence of the ability to change scores on the FMS based on an off-season training program. The results of this study support that an off-season training program can significantly improve scores on the FMS. In addition, the off-season training program significantly increased the percentage of players who scored above the previously determined injury threshold score and also significantly improved the percentage of players who were free of asymmetry. Finally, the results of the study suggest that one of the primary predictors of the inability to improve a player's score above the injury

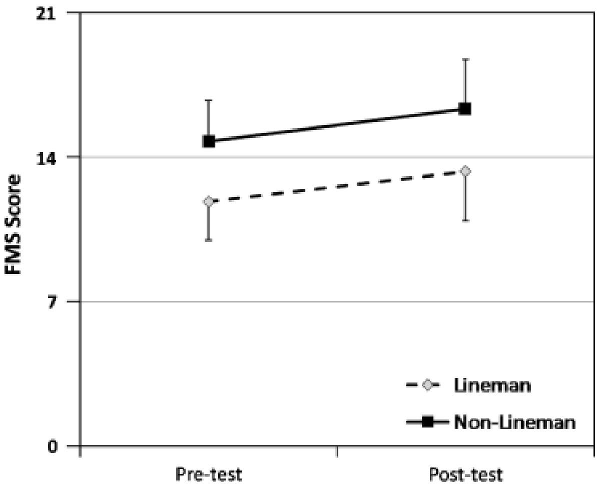


Fig. 1. Composite Functional Movement Screen™ (FMS) scores for non-lineman and lineman before and after the 7-week intervention.

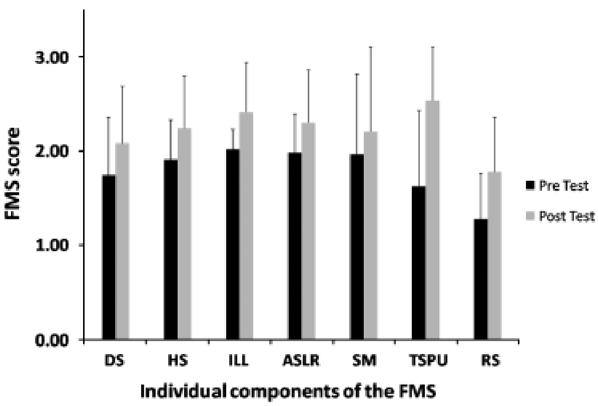


Fig. 2. Mean pre/post-values for the all subjects for each individual component of the Functional Movement Screen™ (FMS). DS, deep squat, HS, hurdle step, ILL, in-line lunge; ASLR, active straight leg raise; SM, shoulder mobility; TSPU, trunk stability push-up; RS, rotary stability.

Table 2. Changes in number of players composite Functional Movement Screen™ score (FMS) and presensce of asymmetries from pre-to post-test

	Pre-test	Post-test	χ^2	P
FMS> = 14	7	30	164.9	<0.01
14>FMS	55	32		
Asymmetry	31	20	7.8	0.01
No asymmetry	31	42		

threshold score was a low score on the deep squat during the pre-test.

While there was no position by time interaction, all players, on average, exhibited an 11% increase in their FMS score as a result of the off-season training program. This suggests that functional movement, as measured by the FMS, can be improved when a structured intervention is applied. While this result is promising, caution should be taken when interpreting this result as no control group was included in this study. It is possible that the changes observed in this study were an affect of repeated measures of test taken at the start and again at the completion of the program. However, while there was no control group, the change in FMS scores from pre-test to post-test ranged from -1 to $+7$ suggesting not all players systematically improved their score as a function of repeated measures.

It is difficult to directly compare our results to other research as we are unaware of any other published study to date which has tested the FMS in this manner. Our results are similar to those reported using other body relative movement tests. Significant improvement in the Star Excursion Balance Test has been reported following standardized intervention programs including Pilates, (English & Howe, 2007) dynamic hop and balance training (McKeon et al., 2008) and functional rehabilitation programs (Hale et al., 2007).

Potentially more important than the absolute improvement in scores was the significant increase in the number of players who scored above the injury threshold at the post-test. At the pre-test only 11% of the players exhibited a score >14 while 63% of players exhibited a score >14 at the post-test. This finding may be of benefit to sports medicine professional who work with professional football players as 52% of the players in the program were able to improve their score from below to above the established threshold score for injury risk (≤ 14).

Although a significant number of players improved their score to >14, the question remains as to why 20 subjects failed to improve their score enough to exceed the threshold of 14. In order to address this issue, a logistic regression model was developed in an attempt to identify if any factors were present which could predict failure (not improving to above a score of 14). The sample size of 32 only allowed us to include three factors into the model selected by the research group, to including position, presence of an asymmetry and scoring a 1 on the Deep Squat test. Position was chosen because of the different movement demands inherent to the different positions in this sport. Asymmetry was chosen because it is a well-known injury risk factor and because we hypothesized that the presence of an asymmetry may be a contributing factor to overall movement limitations. The squat test was included because it involves a balance of mobility (ankles, knees, hip, thoracic spine and shoulders) and stability (pelvic stability to allow the hips to break parallel while maintaining an upright trunk). As a result of the complexity of this task, failure of this test may be an indication of a substantial movement dysfunction in need of an individual examination rather than a basic screen and exercise program. The results indicated that those players scoring a 1 on the Deep Squat Test were approximately 5 × more likely to fail (OR 5.27, 95% CI 1.49–18.65) while the other factors were not shown to be significant predictors of failure. The fact that not all subjects improved their score beyond the threshold of 14 (failure) and that poor deep squat performance was related to failure, suggests that a more robust program may be needed for these individuals to normalize their movement patterns. Perhaps an individual assessment may be required to identify the underlying neuromuscular factors contributing to the persistent dysfunctional movement.

The final area examined was asymmetry of movement, due to the fact that musculo-skeletal asymmetry is a well established risk factor for injury (Ekstrand & Gillquist, 1983; Knapik et al., 1991; Baumhauer et al., 1995; Nadler et al., 2000; Soderman et al., 2001; Plisky et al., 2006; Myer et al., 2008; Yeung et al., 2009). At the pre-test 50% of the players demonstrated asymmetrical movement and this was reduced to 32% following the interventions. This result would suggest that the off-season program was not only able to normalize for poor total body movements but was also able to neutralize some of the asymmetries that were measured in the players.

Some additional limitations of this study should be noted. There was a lack of a control group, therefore, no clear cause/effect relationship can be established without randomization and control. A second potential limitation is associated with the repeated measurement testing which has been previously discussed. Additionally, there was not control for co-interventions. It is possible that some of the subjects were receiving additional intervention such as personal massage or chiropractic care that may have influenced the outcome of the study. Finally, there was no short-term follow-up, perhaps the changes in scores observed occurred much earlier in the program than at the terminal 7-week point. Additional research should focus on examining the change in the FMS as it relates to dosage of a corrective exercise program.

Although the specific results of this study cannot be generalized beyond the population tested, limitations and asymmetries in fundamental movement patterns which are measured by the FMS are basic components of human movement and are not sport specific. Therefore, it may be beneficial to perform additional studies in other active populations.

In conclusion, this study demonstrates that movement can improve with an individualized exercise program. Injury prevention and performance enhancement programs should consider including the FMS or a similar movement screen and associated exercises to normalize dysfunctional movement with the goal of injury reduction and performance improvement.

Perspectives

It is known that previous injury is the most robust risk factor in sport. Although individual components of athletic movement such as strength, flexibility and power are routinely addressed in contemporary rehabilitation, this may not serve as a protective factor against injury. Motor control changes exist following injury and movement oriented testing and training programs to address these deficits are needed in sports (Minick et al., 2009). Recent research (Paterno, 2009), reported that there was no relationship between strength, power, or flexibility and performance on the star excursion balance test. This may indicate that movement oriented tests measure a separate construct which could be helpful in understanding more about motor control changes following injury. The FMS has identified individuals at risk of injury in professional football but it has yet to be determined if an individual's FMS score could be altered by a training program. The results of this study suggest that American professional football players can improve their score with an off-season training program. It has yet to be determined if these improvements will occur in other active populations and if prospective improvements in the FMS actually reduce injury risk. The FMS may be a tool to assist the sports medicine professional in reducing injury risk.

Key words: assessment, injury prevention, motor control.

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