IMPLEMENTING A STANDARDIZED INTERVENTIONAL EXERCISE REGIMEN TO IMPROVE FUNCTIONAL MOVEMENTS IN FEMALE COLLEGIATE ATHLETES

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ABSTRACT

Background: Interventional exercises have been developed to help athletes improve scores on the Functional Movement Screen™ (FMS™). However, there is a paucity of research on the effects of a similar program in female athletes, as well as the effects of a standardized corrective exercise regimen. The purpose of this study was to assess whether an in-season, standardized interventional exercise program improves FMS™ score asymmetry and the composite score of female collegiate athletes.

Study Design: Prospective, quasi-experimental, cohort study

Methods: Forty-one (mean age 19.5 ± 1.2 years; body mass, 70.6 ± 11.5 kg ; height, 1.70 ± 0.083 m) NCAA Division III female soccer ($n = 10$), softball ($n = 17$), and basketball ($n = 14$) players participated in this study. The athletes completed the FMS™ screens prior to their season, regularly participated in four in-season standardized corrective exercises throughout three to four month athletic seasons, and completed the FMS™ screens in the postseason.

Results: The average score of all athletes before the season was 15.52 ± 0.63 and 16.04 ± 0.72 after the season. While the mean score of soccer players increased from 14.80 ± 0.92 to 16.1 ± 1.52 and the mean score of softball players increased from 15.83 ± 1.89 to 16.72 ± 1.41 at the end of the season, the mean score of basketball players dropped from 15.93 ± 1.49 to 15.29 ± 1.59 . Women's basketball players experienced a decrease in their composite FMS™ score ($\bar{x} = -0.571$, $p < 0.01$), while women's soccer players ($\bar{x} = +1.30$, $p < 0.05$) and softball players ($\bar{x} = +1.12$, $p < 0.05$) experienced an increase in mean score 2.28 times and 1.96 times greater in magnitude than the decrease in basketball players' composite FMS™, respectively. Fewer total athletes demonstrated asymmetries at postseason testing, decreasing from 24 at preseason testing to 15 at post-season testing ($p < 0.01$). Significant differences were not noted between athlete age and FMS™ scores ($p > 0.05$).

Conclusions: Standardized interventional programs during athletic teams' seasons may be used to help increase FMS™ scores and reduce asymmetry. Though more studies are warranted to address the negative effects of this standardized program in women's basketball players, this study demonstrated that the number of asymmetries significantly decreased from pre- to postseason among soccer and softball players, which may have implications for a higher resistance to injury.

Levels of Evidence: 3

Keywords: Asymmetry, corrective exercises, female athletes, Functional Movement Screen™ (FMS™), Movement system

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INTRODUCTION

Musculoskeletal injury in the athletic population can be devastating at the individual, team, and organizational levels. Often performance of the team and athlete suffers as a result – which can have both social-emotional and financial consequences dependent on the setting. The involvement of neuromuscular impairment in the pathophysiology of sports injuries prompts interdisciplinary practitioners, including athletic trainers, physical therapists, and physicians, to use screening tools that quantify athletes' abilities to execute functional movements and hopefully reduce injury risk through primary prevention.¹ The Functional Movement Screen™ (FMS™) is a valid and reliable clinical test that evaluates neuromuscular impairments developed by Functional Movement Systems and Gray Cook.² It is comprised of seven functional movements and three clearing tests, and has been used to provide a quantitative measurement of musculoskeletal injury risk.³⁻⁷ Of clinical importance is the ability to effectively identify movement impairments, and potentially decrease the potential for injury, prevent re-injury, enhance performance and ultimately improve quality of life.⁴

A series of work by Kiesel et al. indicate that performance on the FMS™ has implications for risk of injury in a population of professional football players.⁷⁻⁹ One particular trend shown to correlate with a higher incidence of injury was asymmetry in FMS™ scores for movements that assess the extremities. Asymmetry in this context describes differing performance of each extremity (left versus right) when executing a given functional movement, and musculoskeletal asymmetry is a prominent risk factor for injury.¹⁰⁻¹⁴ Players who scored < 14 exhibited at the start of training camp demonstrated a relative risk of 1.87 for time loss injuries over the course of the season. Similarly, players with at least one asymmetry displayed a relative risk of 1.80. The combination of both a low score and exhibiting a movement asymmetry was highly specific (.87) for injury in this athletic population.⁷

Given the use of the FMS™ to gauge injury risk in athletes, it is possible that improvements in FMS™ score and decreased asymmetry correlate with decreased incidence of time loss injuries. Interventional exercises have been developed to help athletes improve

dysfunctional movement patterns, aimed at establishing symmetry and reaching a balance between mobility and stability.^{8, 15} Kiesel et al. utilized off-season interventions with corrective exercises that led to improvements in FMS™ scores for male football players, and Bodden et al. demonstrated that FMS™ scores improved in male MMA fighters after an eight-week interventional program. The work of Bodden et al. also indicated that interventional programs hold potential to establish symmetry in functional movements.¹⁵

However, there is little research on the effects of a similar program on the FMS™ scores of female athletes. While studies have shown no significant differences in the composite FMS™ scores of male and female athletes over the course of an athletic season,¹ similar studies are needed with an intervention in place in order to assess the ability of exercises to change composite FMS™ scores. Furthermore, the corrective exercises instituted by Kiesel et al. and Bodden et al. were unique to each athlete or unique for athletes of a particular sport, which does not address the potential effect of a standardized corrective exercise regimen followed uniformly by athletes across different sports.^{8, 15} Although tailoring exercises to a specific sport or individual athletes is a goal of most practitioners, standardization of exercise offers intervention for a greater number of athletes with less dedication of staffing and time resources, which may be a limiting factor for sports medicine programs.

Consequently, the purpose of this study was to assess whether an in-season, standardized interventional exercise program improves FMS™ score asymmetry and the composite score of female collegiate athletes. The authors hypothesized that a standardized interventional program aimed at improving athletes' functional movements should precipitate improved FMS™ composite scores and reduce asymmetry upon completion of the exercise regimen.

METHODS

Experimental Approach to the Problem

A prospective, quasi-experimental cohort study design was used to analyze changes in the FMS™ after three to four months of in-season interventional

exercises, training, and competitive games in National Collegiate Athletic Association (NCAA) Division III female soccer, softball, and basketball athletes. The athletes completed preseason FMS™ tests before the start of their season as part of their regular preseason evaluation, participated in four standardized corrective exercises as part of routine warm-ups/strength and conditioning programs, and completed postseason FMS™ tests at the end of their respective seasons. Corrective exercises were not conducted during off-season activities. Accordingly, follow up time is measured from the start of each season, and onset of exercise participation, until postseason testing. Athlete recruitment took place in August of 2016, followed by subsequent preseason FMS™ testing. Athletic seasons took place between August 2016 and May 2017 for about three to four months per season, which varied per specific sport. Postseason FMS™ tests were conducted during the last week of each team's respective competitive season.

Subjects

Forty-one (mean age 19.5 ± 1.2 years; body mass, 70.6 ± 11.5 kg ; height, 1.70 ± 0.083 m) NCAA Division III female soccer ($n=10$), softball ($n=17$), and basketball ($n=14$) players participated in this study. This study size reflects female athletes who completed both the preseason and postseason screens, after executing the interventional exercises during their respective competitive seasons. During the regular season for each sport, all subjects participated in team practices and games, which involved three to five court practice sessions and weekly games. The softball and basketball players performed the standardized corrective exercises at the start of their strength-training sessions three times per week with the institution's strength and conditioning staff. Women's soccer did not participate in strength training sessions, and accordingly performed the standardized exercises during weekly practice sessions three to four times per week. Exercises were demonstrated and observed by trained physical therapists at the start of the season. Consistent completion of the exercise regimen was addressed through verbal communication with teams through the course of the season. Data for the preseason and postseason FMS™ was collected by trained physical therapy staff members as standard preseason and postseason

guidelines described by this study. Postseason testing was conducted at team practice sessions to optimize attendance for follow-up testing.

Inclusion criteria for participation in this study included female athletes, ages 18-25, who presented to both preseason testing and postseason testing after participating in the weekly exercises. Exclusion criteria included any injury sustained at the start of the season, which would prevent the athlete from performing the screen, or athletes younger than 18 years of age. The institution's Institutional Review Board for Research with Human Subjects approved this study. Informed consent was obtained from subjects prior to collection of data.

Functional Movement Screen™

A team of five physical therapists and athletic trainers used the Functional Movement Screen (FMS™) to assess the athletes' functional movement patterns. The interdisciplinary team members were experienced in FMS™ scoring to ensure proper evaluation of the subjects. The FMS™ evaluates asymmetry and limitations in seven functional movements through tests including the deep squat, hurdle step, in-line lunge, shoulder mobility, active straight leg raise, trunk stability push-up, and rotary stability. The seven functional movement tests are scored on a scale of 0-3, contributing to a maximum total score of 21.^{2,4-5} Cook et al. describe the exact instructions and grading criteria for completing the seven functional movements tests for the FMS™.³ Each functional movement tests components of strength, stability and flexibility within their respective regions. Observations of movement patterns and compensation strategies can lead the health professional to examine component in isolation. In addition, there are three clearing tests associated with shoulder mobility, trunk stability push-up, and rotary stability to gauge subject pain while executing the functional movement.

Five stations with a scorer, FMS™ test kit, and FMS™ score sheet were set up in a physical therapy studio. The staff scorer at each station instructed the athletes on how to complete the functional movement tested at the station. Due to staffing limitation different scorers were used during the preseason and postseason FMS™; however, previous studies indicate moderate to excellent interrater reliability of FMS™ and

testers discussed grading criteria prior to both pre and post season testing to ensure consistency.^{2,9,16}

After each test was completed at each station, a score from 0-3 was assigned to the subject per FMS™ grading criteria. A score of 0 was given if the subject experienced pain and a score of 1 was given if the subject could not complete the movement or a loss of balance occurred. A score of 2 was assigned if the subject completed the movement without pain, but exhibited a level of compensation to assist in the movement, whereas a score of 3 was given if the subject completed the movement without pain and compensation.^{2, 5-6}

The hurdle step, in-line lunge, shoulder mobility, active straight leg raise, and rotary stability tests are scored separately for the right and left sides of the body, allowing for detection of asymmetry in functional movement. For these tests, the lowest score contributes to the total score assigned for the functional movement test. For example, a right leg score of 1 for the active straight leg raise and left leg score of 2 would translate to a total score of 1 for the active straight leg raise in that subject.

In-Season Activity and Exercises

Following preseason testing, subjects competed in regular season games and participated in four standardized interventional exercises as a part of their routine group warm-up. The exercises were taught by trained physical therapists and incorporated into team warm-ups to ensure equal participation of all subjects. The coaches and team captains monitored the interventional exercises for the soccer players. The team captains and strength and conditioning coaches monitored the interventional exercises for the softball and basketball players. The four standard interventional exercises, each aimed at improving a certain functional movement, included the hard roll, negative push-up, plank hamstring curls, and partner leg-raise (Figure 1). These exercises are not those recommended by Cook et al.,¹⁷ rather these are variations targeted at specific impairments that were identified as deficits at the start of the season across the three recruited teams. Consistently across sports rotary stability was the poorest performing section of FMS™ and this guided exercise selection. The soccer team specifically performed these on

their practice surface and did not have equipment readily available. In addition, only four exercises were chosen, as opposed to more, to increase coach and team member compliance. Table 1 demonstrates the protocol for completion of each exercise and corresponding FMS™ movements.

Statistical Methods

All data were collected and organized using Microsoft Excel. Statistical analysis was conducted and plotted via GraphPad Prism 6 (GraphPad Software Inc., La Jolla, CA USA). Mean and standard deviation were calculated for all FMS™ scores (composite and individual movements), age, height, and weight. Due to limited sample sizes and skewed distributions, the Kruskal-Wallis test (nonparametric) was used to determine any significant differences in the outcome variables (i.e. changes in composite FMS™ scores from preseason to postseason) among the tested sports (softball, soccer, and basketball). When a significant difference was discovered among all participants, Dunn's multiple comparison post-hoc testing was utilized to determine any significant differences between the sports (softball versus soccer, softball versus basketball, and soccer versus basketball) and their respective change in composite FMS™ scores.

As described by Sprague et al. in 2014, a 1-way Chi-squared analysis was performed to determine significant changes between preseason and postseason FMS™ and the number of athletes with asymmetries, using the number of asymmetries at preseason as "expected" values in the Chi-squared analysis.¹ Asymmetries were also analyzed by 2x2 contingency tables (preseason or postseason versus frequency of asymmetries or no asymmetries) with Fischer's test for contingency. Similar analyses were used to determine significant changes in the number of athletes with scores ≤ 1 in any individual movement score. Data pertaining to subjects who only attended preseason testing, and not postseason testing, were not included in any analyses.

RESULTS

Fifty-four athletes initially participated in preseason testing. However, only forty-one (mean age 19.5 ± 1.2 years; mass, 70.6 ± 11.5 kg; height, 1.70 ± 0.083 m) NCAA Division III female soccer ($n = 10$), softball ($n = 17$), and basketball ($n = 14$) players presented to both preseason

Figure 1. Standardized interventional exercises performed by each athlete during team practices, 3-4 times per week. Top to bottom: Hard roll, Negative Push-Up, Plank Hamstring Curls, Partner Leg-Raise.

Table 1. Standardized interventional exercise regimen with corresponding FMS™ screen used for assessment.

Training	Protocol	FMS Screen™
Hard Roll	2 sets, 10 rep.	Rotary Stability
Negative Push-Up	3 sets, 12 rep.	Trunk Stability
Plank Hamstring Curls	2 sets, 10 rep.	Rotary Stability
Partner Leg Raise	2 sets, 10 rep.	Active Straight Leg Raise

and postseason testing after participation in the in-season exercises, and were included in outcome analyses. A total of thirteen athletes (basketball, $n=6$; softball, $n=1$; soccer, $n=6$) presented to preseason testing only, and were not included in the analyses. The average follow-up time, as measured from the start of each team's season to postseason testing, was 111 days, or about 3.7 months.

The average score of all athletes before the season was 15.52 ± 0.63 and 16.04 ± 0.72 after the season. While the mean score of soccer players increased from 14.80 ± 0.92 to 16.1 ± 1.52 and the mean score of softball players increased from 15.83 ± 1.89 to 16.72 ± 1.41 at the end of the season, the mean score of basketball players dropped from 15.93 ± 1.49 to 15.29 ± 1.59 .

Among all athletes tested, softball and soccer players demonstrated the greatest frequency of an increase in composite FMS™ score (**Figure 2**). There was a significant difference between all three sports and the change in composite FMS™ score, as women's basketball players were more likely to experience decreases in their composite FMS™ score ($\bar{x} = -0.571$, $p < 0.01$) (**Figure 3**). In contrast, women's soccer players ($\bar{x} = +1.30$, $p < 0.05$) experienced a positive change 2.28 times greater in magnitude than the decrease in basketball players' composite FMS™. Similarly, softball players ($\bar{x} = +1.12$, $p < 0.05$)

Figure 2. Histogram frequency distributions of (a) Women's softball, (b) Women's soccer, and (c) Women's basketball change in FMS™ testing data depicting differences between preseason and postseason FMS™ scores.

Figure 3. Mean changes (±SD) in FMS™ testing score in women's softball, soccer, and basketball teams (overall $p = 0.009$). *Indicates significant differences in comparison with women's basketball team.

experienced a positive change 1.96 times greater in magnitude than the decrease in basketball players' composite FMS™. Of note, no significant differences regarding changes in composite FMS™ score were noted between softball and soccer players ($p > 0.05$), indicating that the change in composite FMS™ scores between these two groups was similar. Furthermore, no significant differences were noted between sport and individual movement scores ($p > 0.05$).

Fewer total players demonstrated asymmetries at postseason testing ($n_{preseason} = 24$, $n_{postseason} = 15$, $p < 0.01$), with significant decreases in asymmetries in soccer ($p = 0.01$) and softball ($p < 0.01$) players (**Table 2**). The decrease in total asymmetry frequency represented 40% ($n = 4$) of soccer players and 29% ($n = 5$) of softball players. **Figure 4** depicts results regarding asymmetries analyzed with Fischer's test for contingency, indicating a significant decrease in the asymmetries noted among softball players ($p = 0.037$). No significant differences were shown in the number of players with scores ≤ 1 between preseason and postseason testing ($p > 0.05$). Furthermore, significant differences were not noted between athlete age and FMS™ scores ($p > 0.05$).

DISCUSSION

Changes in Composite FMS™ Scores

To the authors' knowledge, there is currently a paucity of evidence regarding the ability to change FMS™

Table 2. Pre- and Post-season asymmetries as measured by the FMS™.

		Asymmetry	No Asymmetry	p-values
Preseason	Softball (n=17)	11	6	-
	Basketball (n=14)	8	6	-
	Soccer (n=10)	5	5	-
	All teams (n=41)	24	17	-
Postseason	Softball (n=17)	4	13	0.0004*
	Basketball (n=14)	10	4	0.28
	Soccer (n=10)	1	9	0.011*
	All teams (n=41)	15	26	0.004*

* = statistically significant improvement, $p < 0.01$

Figure 4. Trend data for asymmetries in softball ($p = 0.0366$), basketball ($p = 0.6946$), soccer ($p = 0.1409$), and all sports ($p = 0.0763$), analyzed by 2x2 contingency tables as opposed to the 1-way [chi]2 analysis. *Indicates significance detected in total asymmetries by the 1-way [chi]2 analysis ($p = 0.004$).

scores based on a standardized interventional program in female athletes from multiple sports. This study was conducted to determine whether standardized exercises designed to address FMS™ movements precipitate improved FMS™ scores regardless of the participant's sport. In settings with lack of ongoing interdisciplinary intervention, standardized exercise may provide a clinically efficient way to promote primary prevention.

The hypothesis that the four prescribed, standard exercises could improve athletes' FMS™ scores

universally was not supported by this study. Though the mean score of all athletes increased at postseason, examining team-specific scores argues against a uniform increase in scores. The novel finding of this study was that women's soccer and softball players experienced an increase in composite FMS™ scores with reduced asymmetries after performing the same four standardized warm-up exercises; however, the women's basketball players experienced a small net negative change in composite FMS™ scores with increased asymmetries.

In a cohort of professional football players, on average there was an 11% increase in their FMS™ score as a result of the interventional training program,⁸ which is a greater change than what was experienced in this cohort. The preseason average FMS™ scores noted in this study were higher than the average of 14.3 ± 1.77 among female athletes recorded by Chorba et al.¹⁸ Accordingly, the results from this study differ from past studies that have demonstrated the ability of intervention programs to more uniformly increase FMS™ scores within a cohort of athletes.^{8,15} However, those studies contrasted from this current study in two significant ways. Specifically, this study examined a larger cohort of athletes than Bodden et al.'s study, and this cohort featured athletes from three different sports.¹⁵ Moreover, the differing results may represent a manifestation of gender differences, as this cohort featured solely female athletes, compared to the male MMA athletes and professional football players featured in Kiesel et al. and Bodden et al.'s work. In addition to gender differences, this study featured Division III athletes as opposed to more high-performing semiprofessional MMA fighters and professional American football players. Furthermore, the athletes in this study all completed the same four exercises during their warm-up routines regardless of their sport, as opposed to individualized training programs prescribed by Kiesel et al. and Bodden et al. to their subjects. Although individualized, sport-specific training would be preferred, as supported by the aforementioned studies, this study aimed to develop an exercise regimen that could be implemented across sports with fewer healthcare providers in order to improve functional movement scores in this study's patient population.

Though the improvement in FMS™ scores observed in the women's soccer and softball athletes supports previous findings that FMS™ composite scores may be improved by corrective exercises, this study shows that interventional exercises may be standardized only for certain sports.⁸ However, it is important to keep in mind that the negative change in composite FMS™ score of 0.64 points from preseason to postseason in the basketball cohort is less than the minimally clinically important difference (MCID) for the FMS™ composite score of 1.25 points indicated in previous literature.¹⁹

The discrepancy between the changes observed in basketball players' individual limb FMS™ scores versus that of the other athletes might indicate the need for sport-specific interventional exercises. The increases in composite FMS™ scores of softball and soccer players indicate that the standardized exercises should have helped increase FMS™ scores without a tropism for upper or lower body dominant sports. However, the basketball players' relatively poor response to the standardized exercises suggests that those athletes were subject to different factors affecting their functional movements, compared to softball and soccer players. The basketball players' FMS™ performance did include some "0" scores due to pain and/or inability to complete the movement although there was no time loss injury associated. Limitations and decreased ability to perform the functional movement occurred over the course of the season, which limited functional scoring but did not limit sport performance. Different interventional exercises specific to the deficits in the basketball players' FMS™ performance may allow for reversal of their negative trend in FMS™ performance in future seasons. Additionally, consideration of dosing, technique and other potential interventions may also need to be considered in the future.

Asymmetries

Asymmetries from the hurdle step, in-line lunge, shoulder mobility, active straight leg raise, and rotary stability tests reflect differences in scoring between the right and left side of the body. In this cohort, a significant overall reduction in the number of asymmetries recorded at postseason testing

as compared to preseason scores was observed, particularly in softball players (**Table 2, Figure 4**). Though the overall number of asymmetries was reduced in the combined cohort of athletes, the basketball cohort actually experienced a slight increase in the number of players with asymmetry in scores. This finding represents a distinct deviation from the trend observed in softball and soccer players. Though the observed increased asymmetry in basketball players may represent a true finding, it is possible that this phenomenon may be due to errors in instruction from the basketball team staff. Specifically, improper technique may have favored one side of the body over the other, causing an augmentation of asymmetry that compounded with asymmetry introduced by playing basketball through the season (i.e. inherent left or right handed preference for dribbling, shooting, or passing). In contrast, the reduction in the number of asymmetries in the women's soccer and softball players' scores from preseason to postseason suggests potential of using these standardized interventional exercises to minimize asymmetry in athletes. These exercises then may provide a protective effect in soccer and softball players, as higher rates of asymmetries in scores has been linked with a higher risk of athlete injury.⁷ The increase in the number of players with asymmetry in scores in the basketball cohort suggests an added detrimental effect for those athletes in addition to their decreased postseason FMS™ scores.

Limitations

The sample size and lack of a control group within this study represent key limitation in the ability to detect significant patterns resulting from the implementation of the standardized exercises. A larger number of participants would have allowed for emergence of significant patterns between the subjects' sport and changes in the individual movement scores on the FMS™. Likewise, use of a control group would allow more confidence in the effectiveness of interventional exercise versus improved strength, stability and motor control specifically related to in-season training and competition alone.

The quality of exercises performed by the teams may have varied, as team captains and coaches supervised soccer players, while strength-training

staff supervised basketball and softball players. This study solely involved NCAA Division III athletes, who may have varying athletic abilities compared to their Division I or II counterparts, limiting generalizability to athletes of other divisions. Furthermore, inclusion of athletes from only three different sports further limits generalizability to athletes playing those sports not represented in this study. Similarly, differences in coaching technique and philosophy, skill acquisition and sport specific biomechanics were not taken into consideration as a possible influence in improving FMS™ scores.

Additionally, this was not a randomized, blinded study, which may influence the extent to which one may interpret these results. However, past studies have shown that, in the absence of an intervention, there are no significant differences in composite FMS™ scores over the course of certain athletic seasons.¹ Thus, the statistically significant findings in this study may be compared to those results, indicating that interventional exercises may indeed change composite FMS™ scores in certain athletes. Future studies should assign corrective exercises in the context of a randomized, blinded study design, with a control group in order to attain more robust analysis regarding changes in FMS™ score or asymmetry from pre- to postseason.

Lastly, though these results provide an understanding of potential trends over the course of one season and may be applicable to other athletes, continued studies over future seasons may help determine the long-term effect of these exercises on athletes' FMS™ scores and number of asymmetries.

CONCLUSIONS

The ability to improve athlete scores through interventional exercises allows for the creation of preventative training regimens that provides practitioners an opportunity to maintain or improve athlete performance. The results of the current study suggest that a standardized interventional program implemented during certain athletic teams' respective seasons can increase FMS™ scores and reduce asymmetries. Though more studies are warranted to address the negative effects of this standardized program in women's basketball players, this study demonstrated that the number of asymmetries

significantly decreased from pre- to postseason in soccer and softball. Further research with an expanded sample size should also examine the effects of sport-specific exercises and improved standardization of performance of exercises, as well as long-term effects of such interventions.

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