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Functional movement screen comparison between the preparative period and competitive period in high school baseball players

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ABSTRACT

Background/Objective: Although the functional movement screen (FMS) has been widely applied for screening athletes, no previous study has used FMS scores to examine the association between distinct training seasons in high school baseball players. The aims of this study were to ascertain the functional movement screen (FMS) scores differences between the preparative period (PPP) and the competitive period (CPP) among high school baseball players and further determine whether FMS can be used as a tool to predict injuries during two major periods.

Methods: Fifty-five male high school baseball players (age 15.3 ± 1.7 years; height 1.7 ± 0.8 m; weight 64.6 ± 11.5 kg) volunteered. Athletic injuries were reported through a self-report questionnaire. Players performed the FMS during the PPP and the CPP. A receiver operator characteristic (ROC) curve to calculate a cutoff total composite score ≤ 14 for the relationship between the FMS score and injury. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and an area under the curve (AUC) were calculated.

Results: FMS individual task score and total composite score were significantly lower in the CPP than in the PPP. However, a cutoff total composite score ≤ 14 for risk of injury, determined through a ROC curve, represented a low sensitivity of 58%, NPV of 66%, an AUC of 69%, specificity of 79%, and PPV of 71%.

Conclusion: Although the low sensitivity and NPV and AUC scores indicated that the FMS does not accurately predict the risk of injury, the FMS individual task and total composite scores differed significantly between the PPP and CPP. Therefore, FMS could be used as a tool to identify physical deficiencies between distinct training seasons; however, utilizing the FMS as a screening tool for injury prediction in particular during the CPP in this population would not be recommended.

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Introduction

Early prevention and management of sports injuries is a strategy that plays a critical role in reducing athletic injury and enhancing exercise performance. Preventing injury is one of the main responsibilities of sports medicine staff at all levels of athletics.¹ Specifically, players' movement capability requires judicious

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monitoring and routine recording during distinct training periods. Poor functional movement capability resulting from strength and range-of-motion (ROM) biomechanical abnormalities might be expected following athletic injury.² However, in several cases, strength imbalances and muscle flexibility might not be detected if traditional assessment methods are used.^{3,4} A potential tool that could facilitate overcoming this drawback is the functional movement screen (FMS). The FMS is a tool used for objective screening of athletes' body mobility, stability, and movement control. The FMS comprises seven fundamental movement tasks including deep squat (DS), hurdle step (HS), in-line lunge (ILL), shoulder mobility

(SM), active straight leg raise (ASLR), trunk stability push-up (TSPU), and rotary stability (RS). This tool is a screening assessment that offers high intertester and intratester reliability when used by clinicians, physical therapists, and athletic trainers in the evaluation of deficits in specific functional movement patterns.^{5–10}

FMS applications have been extensively investigated in collegiate students⁴ and adults.^{11,12} The previous study used the FMS to demonstrate changes in the functional movement patterns of volleyball and soccer players between pre-competitive and post-competitive periods; individual scores for the ASLR and RS declined among all athletes during the post-competitive season.¹³ Furthermore, previous study reported that an FMS score of ≤ 14 was associated with a 4-fold increase in the likelihood of lower-extremity injury in NCAA Division II athletes in sports such as soccer, volleyball, and basketball.¹⁴ Likely, another study showed that professional football players who scored ≤ 14 on the FMS assessment carried an 11-fold increased risk of injury and presented a 51% probability of sustaining a serious injury over the course of one competitive season.¹

Although numerous studies have investigated FMS among collegiate students and adults, relatively few studies have been published on the use of FMS among adolescents, particularly in high school baseball players. Only one FMS study specifically investigated high school baseball players. This study used the fundamental movements of the FMS as a 16-week FMS training program; the results demonstrated that the hand-grip strength and bench-press strength of the athletes had increased by 12% and 9%, respectively, at the end of the training course.¹⁵ However, no previous study has used FMS scores to examine the association between distinct training seasons in high school baseball players. Among baseball players in the National League and American League, the majority of injuries were to the upper extremities (51%). Lower extremity, spine and core, and other injuries accounted for 31%, 12%, and 6% of the total injuries, respectively, during the various seasons in a baseball player's year.¹⁶ Given the importance of functional movement patterns for team sport athletes, there is value for strength and conditioning professionals to understand whether FMS is used as a tool to examine preseason training and in-season competition for baseball players, and promptly identify physical deficiencies. The preparative period (PPP) consists of the general strength and conditioning training, specific skill and tactical training, the purpose of this phase was to develop the factors needed for a peak performance. During competition period (CPP), when players during base running or chasing fly balls are more likely to play more competitively and harder for the win. Consequently, players may increase incidence of injuries during games is owing to the effect of higher intensity in corresponding to 2-fold shoulder injuries and 3-fold elbow injuries.¹⁷ Therefore, the aims of this study were to 1) use the FMS to investigate the differences between the PPP and the CPP among high school baseball players, and 2) further determine whether FMS can be used as a screening tool to predict musculoskeletal injuries, in particular during the CPP.

Methods

Participants

The participants were fifty-five male high school baseball players (age = 15.3 ± 1.7 years; height = 1.7 ± 0.8 m; body mass = 64.6 ± 11.5 kg; body mass index = 22.5 ± 3.4 kg/m²) from Taiwan. Before data collection, we excluded participants who had 1) previously sustained severe neuromuscular injuries, such as fractures, second- and third-degree ligament sprains and muscle strains, and joint subluxation or dislocation; 2) undergone

surgical procedures; or 3) experienced head or spinal injury or visual, vestibular, or balance disorders during the preceding 3 months. Participants with previous FMS experience were also excluded to avoid the possibility of bias caused by familiarization.¹⁸ The investigation was approved by Institutional Review Board. All participants and guardians were informed of the benefits and risks of the study. Written informed consent was obtained from the participants and their guardians before data collection.

Procedures

Data were collected at an outdoor training site on a high school campus. The athletes wore athletic clothing and running shoes during the study. An FMS instructor with the certified athletic trainer measured the FMS scores for all participants during the PPP (1st FMS) and CPP (2nd FMS). First FMS testing during PPP occurred in Feb just start the in-season; 2nd FMS testing during the CPP occurred in May at the end of the in-season (Fig. 1). In addition, injuries were reported to the athletic trainer through a self-report questionnaire. All tasks were performed according to the standardized procedures and the verbal instructions developed by Cook.¹⁹ For this investigation, the athletic injury was defined as any musculoskeletal pain complaint, on or off the field, between the PPP and CPP, and it included the following criteria: injury assessed by an orthopedic doctor, certified athletic trainer, or licensed physical therapist.

Functional movement screen testing

The FMS comprises seven fundamental movement tasks and three clearance tests. Each FMS is scored using an ordinal scale (0–3) to obtain a composite score (0–21); the scoring criteria are shown in Table 1. With respect to the seven movement tasks, the participants were assessed by their DS, HS, ILL, SM, ASLR, TSPU, and RS performance. Only verbal instructions without any coaching were allowed during the screening process. In the three clearance tests, the participants were assessed for any pain during shoulder flexion corresponding to horizontal adduction and internal rotation (shoulder impingement test), end-range spinal flexion (spinal flexion test), and end-range spinal extension (spinal extension test). When a participant experienced pain during any portion of a movement, the corresponding FMS component movement was assigned a score of 0. The FMS has been shown to exhibit high intertester (0.843) and intratester reliability (0.869), which were established by calculating the intraclass correlation coefficient.²⁰ Furthermore, the reliability scores obtained from novice and expert raters showed close agreement.⁶ In this study, the intratester reliability was 0.851, which suggested high reliability.

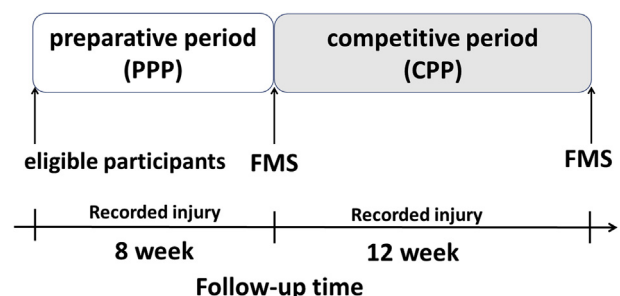


Fig. 1. The time frame of the experimental design.

Table 1
Functional movement screen scoring criteria.

Score	Description
3	Perform correctly complete the movement without any compensations
2	Perform the movement with any one of specific compensations
1	Perform the movement with complete compensations or inability to perform the movement
0	Occurrence of pain during any the movement

Statistical analysis

This was a longitudinal cohort study (pretest-posttest design). All data were displayed as means \pm standard deviations. Statistical analyses were performed using the SPSS v. 17.0 software package. The data were normally distributed according to the Shapiro–Wilk test and the homogeneity of variance was confirmed using Levene's test. In this study, because normality was observed ($P = 0.07$) in the FMS total scores, a parametric paired Student t-test was used to analyze the total scores for the PPP and CPP comparisons. However, since violations of the normality was observed ($P < 0.05$) in the FMS individual scores, a non-parametric Wilcoxon signed-rank test was used to analyze the individual scores between two time periods.

A receiver operator characteristic (ROC) curve was used to calculate a cutoff total composite score ≤ 14 that maximized both sensitivity and specificity for the relationship between the FMS score and injury.¹ Therefore, this study in particular during the CPP also used a ROC curve, which is a plot of sensitivity (true positives) versus $1 - \text{specificity}$ (false positives), to determine a cutoff total composite score for the FMS. Distinct points on the curve correspond to different cutoff points. After establishing the cutoff score, a 2×2 contingency table was generated that divided players who suffered an injury and players who did not as well as players above and below the cutoff score on the FMS. Sensitivity, specificity, positive predictive value, and negative predictive value (NPV) were calculated. Differences were considered significant at $P < 0.05$. Differences were considered significant at $P < 0.05$.

Results

The following FMS task scores in the CPP were significantly lower than those in the PPP were: DS ($P = 0.031$), HS ($P < 0.001$), SM ($P = 0.043$), TSPU ($P = 0.01$), and RS ($P = 0.006$; Table 2); however, no significant differences were found for ILL ($P = 0.498$) and ASLR ($P = 0.76$; Table 2). In comparisons of the seven specific movements between the CPP and PPP periods, the reduced mean difference in addition to the difference in ratio for HS, DS, and RS were observed. Moreover, the FMS total composite score in the CPP was significantly lower than that in the PPP ($P < 0.001$; Table 2).

The number of injuries was higher in the CPP than in the PPP in the current study. During the CPP, there were 26 players (47.2%)

recorded injuries, but they did not result in missing any one game. These injuries identified as first-degree muscle strains or ligament sprains were recorded at the following sites: shoulder, 7 (26.9%); elbow, 6 (23.1%); lower back, 6 (23.1%); thigh, 3 (11.5%); leg, 2 (7.7%); and ankle, 2 (7.7%). In contrast, during the PPP, only 4 players were recorded injuries including 2 shoulders, 1 elbow and 1 thigh injuries, players also did not result in missing any one game.

According to the ROC curve and its corresponding table of sensitivity and $1 - \text{specificity}$ values (Fig. 2), the FMS total composition score that corresponds to the upper left hand aspect of the graph was between 13.5 and 14.5. Therefore, the cutoff point was chosen to be 14. The participants were divided into groups according to this cutoff point and their injury status. This cutoff score represented a sensitivity of 58%, specificity of 79%, positive predictive value of 71%, negative predictive value of 66%, and an area under the curve (AUC) of 69% (Table 3).

Discussion

Whether the FMS can be used as a tool to predict injuries remains controversial. Some studies have shown a degree of predictive ability for identifying athletes who are at a higher risk of injury, but others have proposed no predictive capabilities for the FMS based on low sensitivity and a low AUC.^{18,21–28} Taken together, the methodological limitations identified by previous systematic review suggest the predictive validity of the FMS may be different in the current aggregated analyses. In particular, a variety of injury definitions and participants, such as military personnel and professional and collegiate athletes, reported diverse outcomes.^{29–36} Moreover, the FMS result between distinct training seasons in high school baseball players remains unclear, which may provide strength and conditioning professionals to promptly identify physical deficiencies. Therefore, we first investigated a longitudinal study to compare the differences between the PPP and CPP by using the FMS tool and further determined whether FMS can be used as a screening tool to predict musculoskeletal injuries. Our results highlighted that the difference in FMS scores between the PPP and CPP was statistically significant in high school baseball players, indicating physical deficiencies. In a word, athlete during CPP significantly reduced fundamental movements, which are characterized by the necessity of range of motion, flexibility,

Table 2
Differences in the FMS individual task scores and total composite scores.

	Preparative period (PPP)	Competitive period (CPP)	Mean differences (CPP - PPP)	Difference ratio (%)	P value
Deep squat (DS)	2.22 \pm 0.76	1.9 \pm 0.58	- 0.32*	- 14.4	0.031 ^b
Hurdle step (HS)	2.29 \pm 0.46	1.85 \pm 0.42	- 0.44***	- 19.2	<0.001 ^b
In-line lunge (ILL)	2.29 \pm 0.6	2.37 \pm 0.54	0.08	3.5	0.498 ^b
Shoulder mobility (SM)	2.66 \pm 0.53	2.39 \pm 0.81	- 0.27*	- 10.2	0.043 ^b
Active straight leg raise (ASLR)	2.02 \pm 0.47	2.0 \pm 0.55	- 0.02	- 1.0	0.76 ^b
Trunk stability push-up (TSPU)	2.54 \pm 0.81	2.2 \pm 0.9	- 0.34*	- 13.4	0.01 ^b
Rotary stability (RS)	1.83 \pm 0.38	1.54 \pm 0.6	- 0.29***	- 15.8	0.006 ^b
Total score	15.85 \pm 2.17	14.34 \pm 2.12	- 1.51***	- 9.5	<0.001 ^a

Significant differences between the PPP and CPP (* $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$).

^a Parametric paired Student t-test.

^b Non-parametric Wilcoxon signed-rank test.

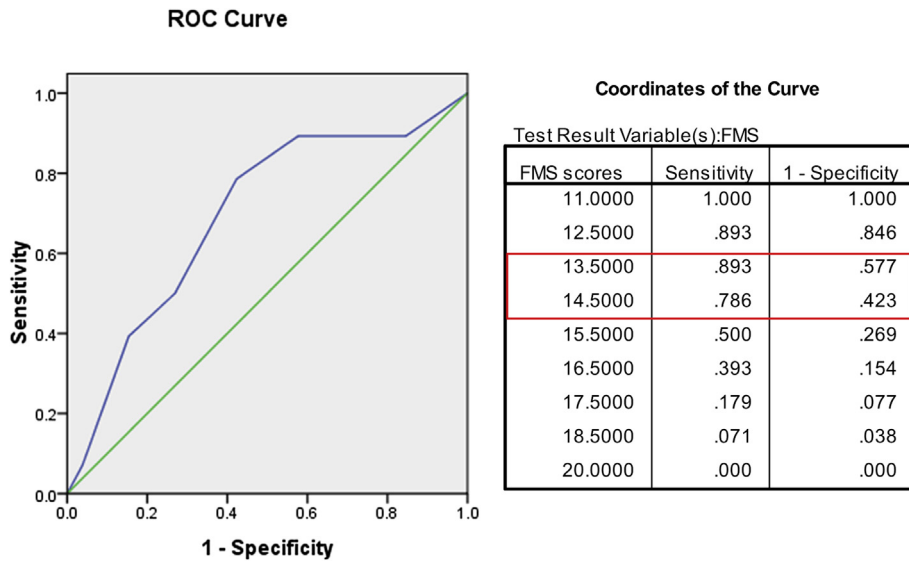


Fig. 2. ROC curve and its corresponding table of sensitivity and 1 – specificity values during the competitive period.

Table 3
2 × 2 contingency table for all players.

FMS score ≤14?	Injury?		Predictive Value
	YES	NO	
YES	15	6	Sensitivity: 58% Specificity: 79% PPV: 71% NPV: 66% AUC: 69%
NO	11	23	

FMS, Functional Movement Screen; PPV, positive predictive value; NPV, negative predictive value; AUC, area under the curve.

stability and balance. However, the low sensitivity and NPV and AUC scores indicated that the FMS does not accurately predict the risk of injury in this population.

Additional studies showed that the lack of functional movement patterns in athletes can impair the efficiency and effectiveness of their motion performance capability and techniques.^{10,37} The findings of the present study provide a further understanding of the changes in movement capability in high school baseball players between the PPP and the CPP. We speculated that the potential reasons for these differences: the athletes during PPP are being typically with an emphasis on building up strength and conditioning, lower intensity play, more greatly conditioned and skilled. In contrast, athletes during CPP are thought to be the greater and increased intensity play in order to win, resulting in performing more risky behaviors and excessive stress on body structure. For instance, a higher injury rate (i.e., acute muscle–tendon strain or ligament sprain) and physical deficiencies. Therefore, the DS, HS, SM, TSPU, and RS scores and the total composite score in the CPP were all significantly lower than those in the PPP (Table 2). We speculated that athletes were required to execute specific technical tasks and coordinated actions on the field during the CPP, the lower- and upper-extremity muscle groups in the athletes are maintained in a state of increased tension, which is reflected in the form of enhanced biomechanical changes in multijoint and multi-planar action. A previous study showed that in baseball players, high lower-extremity strength and endurance are required to facilitate dynamic stabilization when performing tasks.³⁸ Furthermore, the previous study reported that hip and trunk motion in

rotational patterns can affect shoulder motion by proximal-to-distal sequencing in kinetic chains.³⁹ The large muscle groups of the hips and trunk provide stability for positioning the thoracic spine to accommodate proper shoulder motion.⁴⁰ Further research is necessary to assess the kinetic or kinematic differences between the PPP and CPP.

Here, we found that the total composite score for predicting the risk of injury indicated a low sensitivity, NPV, and AUC (Table 3), suggesting, in agreement with previous studies, that the FMS total score is a poor injury risk predictor.^{21,22} Furthermore, our results revealed a higher number of injuries in the upper extremities (shoulder 26.9%, elbow 23.1%) than in the lower extremities (thigh 11.5%, leg 7.7%, and ankle 7.7%), which are common injury among overhead throwing players. Competitive pitchers have been reported to generate forces reaching 100% of their body weight at the elbow and higher forces at the shoulder.^{41,42} Furthermore, Hannon et al.² reported that ulnar collateral ligament damage can cause marked lower-extremity balance deficits in high school and collegiate male baseball players.

Further research must be conducted to ascertain the FMS scores for athletes according to distinct ages and playing positions to identify correlations between movement qualities assessed by the FMS and various intrinsic risk factors. Moreover, the mechanism underlying a reduction in FMS scores could be investigated by performing isokinetic muscle tests, recording EMG activity, and conducting physiobiochemical analyses in a laboratory setting. Finally, the effects of specific intervention courses, such as core muscle training, stretching exercises, or corrective exercise therapy, measured using individual FMS task scores and total composite scores must be elucidated to determine whether these interventions effectively improve movement quality.

In conclusions, although the low sensitivity and NPV and AUC scores indicated that the FMS does not accurately predict the risk of injury, the FMS individual task and total composite scores differed significantly between the PPP and CPP. Therefore, FMS could be used as a tool to identify physical deficiencies between distinct training seasons; however, using the FMS as a screening tool for injury prediction in particular during the CPP in this population would not be recommended. For future practical implications, the FMS could be advantageous for screening movement dysfunctions in the distinct training seasons. These results highlight that the FMS

total composite score was lower in the CPP than in the PPP. The basic fundamental movements covered in the FMS involve diverse aspects of strength, conditioning and motor control. When weaknesses are exposed, the FMS composition and total score decrease. Therefore, by screening these fundamental movements during the PPP and CPP, strength and conditioning professionals can promptly identify functional limitations.

Conflicts of interest

The authors have no conflicts of interest relevant to this study.

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