Clinical Trial/Experimental Study

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Effects of functional movement screen training in high-school baseball players

A randomized controlled clinical trial

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Abstract

Background: In recent years, the functional movement screen (FMS) and FMS training have attracted attention as a means of preventing injury, but no studies have examined the effect of such training in high-school baseball players. The aim of this study was to clarify the effect of FMS training on FMS score, physical function and baseball performance in high-school baseball players.

Methods: Subjects in this randomized controlled clinical trial were high-school male baseball players assigned to either an FMS training group (intervention group) or a control group. The intervention group performed FMS training 4 times per week for 12 weeks. FMS ability, physical function, and baseball performance were measured prior to the intervention, 8, 12, and 24 weeks after the intervention in the subjects' school environment.

Results: A total of 71 baseball players aged 15 to 17 years were recruited and assigned to either an intervention group (n=37) or control group (n=34). There was no significant difference in the characteristics of participants between the 2 groups. Most FMS scores improved to 12 weeks after continued training. In the intervention group compared with the control group, deep squat, hurdle step, inline lunge, active straight leg raise, trunk stability push-up and rotary stability FMS score, total FMS score and eyes closed single leg stance time significantly increased after 8 weeks of training. While hurdle step, inline lunge, active straight leg raise, trunk stability push-up, total FMS score, and eyes closed single leg stance time significantly increased, pitching ball speed significantly decreased at the end of the 12 week training period. Eyes closed single leg stance time and feeling of fatigue significantly improved 12 weeks after training. The number of subjects who scored less than 14 for the total FMS score in the intervention group compared with control group were significantly less after 8 and 12 weeks of FMS training.

Conclusion: FMS training for 8 weeks contributes to improving FMS scores for high-school baseball players, but FMS scores go down if FMS training is not continued.

Trial registration: University Hospital Medical Information Network Center, Tokyo, Japan: UMIN000027553. Registered on May 30, 2017.

Abbreviations: FMS = functional movement screen, NRS = numerical rating scale, ROM = range of motion.

Keywords: baseball, FMS training, functional movement screen, high-school player, injury prevention

1. Introduction

Baseball requires various functional activities including throwing, batting, running, and catching. In Japan, high-school baseball players are commonly screened to identify potential risk factors for injury during baseball training and competition. In general, this screening process includes measurement of range of motion (ROM) for flexibility[1,2] and checking for abnormality on imaging such as computerized tomography[3,4] or ultra-

Editor: Satish Prasad Barnawal.

Informed consent was obtained from all participants.

The authors declare no conflicts of interest associated with this manuscript.

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

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How to cite this article: Suzuki K, Akasaka K, Otsudo T, Sawada Y, Hattori H, Hasebe Y, Mizoguchi Y, Hall TM, Yamamoto M. Effects of functional movement screen training in high-school baseball players: A randomized controlled clinical trial. Medicine 2021;100:14(e25423).

Received: 26 August 2020 / Received in final form: 26 February 2021 / Accepted: 27 February 2021

http://dx.doi.org/10.1097/MD.0000000000025423

sound.[5,6] However, these medical checks do not target functional evaluation. In recent years, functional movement screen (FMS) has been used as a screening process thought to prevent sport injury.[7–14] This system is believed to evaluate the athlete's whole-body movement patterns and may be used as a tool to assist in determining readiness to return to sport at the completion of rehabilitation after injury or surgery.[15]

FMS consists of 7 functional tasks involving movement patterns of the trunk as well as upper and lower extremity. Each task is scored according to ability, with a maximum of 3 points indicating sound task completion (21 points indicates a perfect total score).[15,16] In order to improve the FMS score, a training system using no-load exercises, kettle bells, core boards, and cable machines is recommended for the purpose of developing bilateral symmetry, trunk stability, movement patterns, and proprioception.[15,16] The FMS score has moderate to good reliability, yet moderate to poor validity. Meaning that different clinicians rate athletes the same on the FMS score, yet the concept of a composite score predicting injury risk may not be a valid hypothesis.[17,18]

Previous studies have reported an estimated cut-off value for the total FMS score at which athletes are at risk of injury. For instance, female college athletes with FMS scores of 14 or less had a quadrupling of lower extremity disorders.[9] Injury risk during the playing season was 11 times greater in professional football players with FMS scores of 14 or less.[12] In addition, it has been shown that there is a relationship between FMS scores and injuries, with a lower FMS score associated with a higher probability of injury.[8] These reports suggest that poor FMS performance may be an indicator of injury risk. Therefore, the FMS rating system may appear useful to evaluate the functional movement of adolescent baseball players to identify training to improve FMS capability for the purpose of preventing injury.

FMS training consists of no-load exercises, kettle bell training, core board and cable machine exercises.[7,13,14,19,20] According to the recommendation from Song,[14] fascial release using a foam roller over the gluteus maximus, quadriceps femoris, tensor fasciae latae, hip adductors, hamstring, triceps surae, latissimus dorsi, and back muscles can also help to improve the FMS score. In that study, trunk training (side planks, curl up, trunk stability) were also undertaken in the intervention group.[14] So, it is considered necessary to include core training and foam rollers in FMS training studies.

Despite this evidence, there are no studies that have evaluated the FMS system in Japanese adolescent baseball players, or whether the training system impacts on injury prevention or sports performance. The aim of this study was to identify whether FMS training improves FMS scores, physical function, and baseball performance in high-school baseball players. If FMS training improves FMS scores, it may be considered a component of injury prevention programs. It was our hypothesis that FMS training in elite high-school youth baseball players would improve FMS score.

2. Methods

2.1. Participants

We recruited participants for the study from April 2017 to June 2017. The subjects of this randomized controlled clinical trial were high-school baseball team players who consented to take part in the study. Players were selected from the top 32 schools in the Saitama prefecture high-school baseball championship. Exclusion criteria were players who had difficulty practicing or intervening due to injury. All players were randomized due to the risk of team-based practice affecting the results. Randomization was achieved using the envelope method. The randomization procedure was performed by drawing a sealed opaque envelope containing assignment to the intervention or control group. The number of envelopes had been adjusted to match the number of players. One physiotherapist (KS) created an allocation, enrolled participants, and assigned players to each group.

2.2. Sample size

Prior power analysis was performed to determine the appropriate sample size to achieve statistical significance at 80% power ($1-\beta$). The sample size was calculated by the power analysis application (G * Power 3.1.9.4, http://www.gpower.hhu.de/). To compare the FMS scores of both groups, the Mann–Whitney test set the effect size w to 0.5 ($\alpha=0.05$, $1-\beta=0.8$), resulting in 134 cases. Furthermore, to compare the number of people with FMS scores of 14 or more in both groups, the effect size w was set to 0.3 ($\alpha=0.05$, $1-\beta=0.8$) in χ^2 test, and the sample size was 88 cases. Therefore, we tried to recruit at least 134 subjects for this study.

2.3. Measurement

Age, height, weight, years of baseball experience, dominant hand, and field position of the participants were recorded by a questionnaire. From September 2017 to March 2018, FMS score as a primary outcome, eyes closed single leg stance time, fatigue over the previous week, pitching ball speed, and baseball performance as secondary outcomes were also measured before the intervention, and at 8, 12, and 24 weeks after the intervention in their school environment. The FMS comprised 7 tasks including deep squat (Fig. 1A), hurdle step (Fig. 1B), inline lunge (Fig. 1C), shoulder mobility (Fig. 1D), active straight leg raise (Fig. 1E), trunk stability push-up (Fig. 1F), rotary stability (Fig. 1G).[15,16] Each task was carried out using the standard FMS measurement kit (1.2 m bar, 2 cm by 60 cm bar, 5 cm by 15 cm box). Seven movement tasks were scored with a maximum of 3 points per task. The deep squat comprised the deepest squat possible by holding a 1.2 m bar above the head and slowly lowering the body so that the toes did not face outward. In the hurdle step, the toes must stay in contact with the center of the base, the bar is placed on both shoulders, the back is kept straight, the hurdle is straddled, and the straddling foot is returned to the starting position. The inline lunge comprises a lunge posture with a 1.2 m bar placed on the head, and in contact with the thoracic spine and sacrum. The subject lunged up and down.[15] Shoulder mobility was assessed by reaching one hand down from the neck while the other reached up from the lumbar spine. The distance between the hands was measured. The Active straight leg raise was evaluated in supine. The lower extremity on the test side was raised up while maintaining the contralateral extremity in the starting position. The trunk stability push-up commenced from prone, performing a push-up while maintaining neutral spinal alignment. For rotary stability, the starting position was 4-point kneeling. A 5×15 cm beam was placed between the hands and knees. Starting with the hand and knee on one side on the beam, they reached the arm forward and leg back to until level with the ground, before returning to the starting position. If this was too

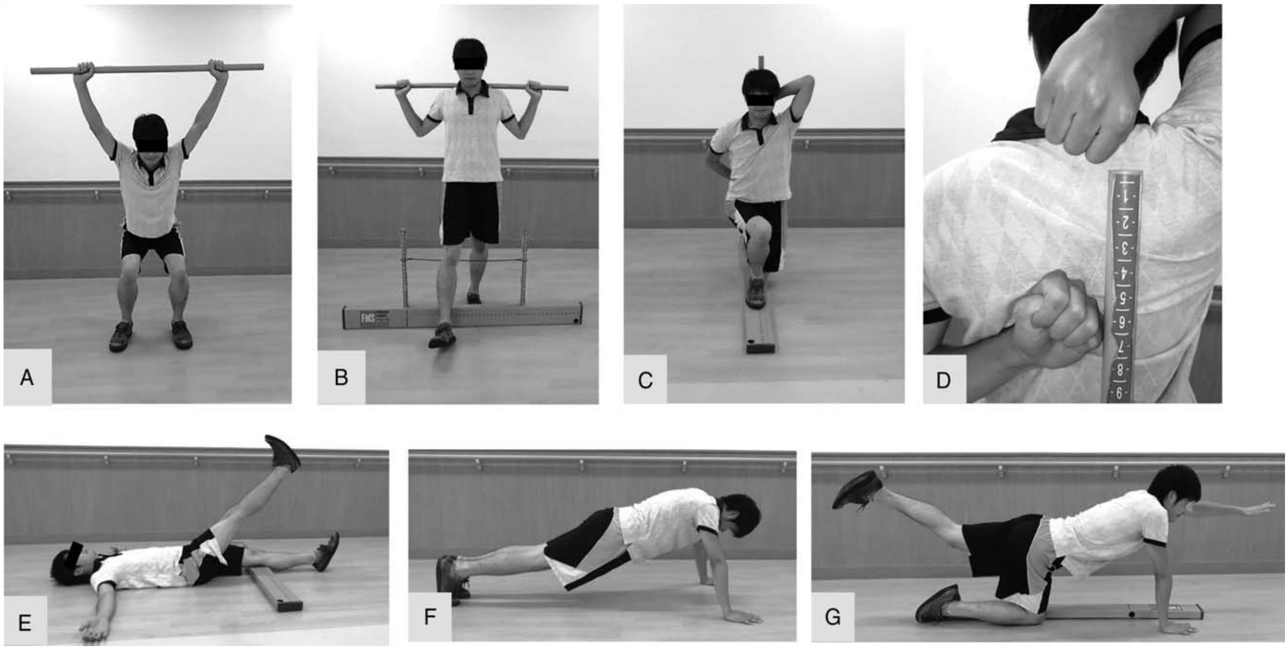

Figure 1. Functional movement screen. A: deep squat, B: hurdle step, C: inline lunge, D: shoulder mobility, E: active straight leg raise, F: trunk stability push up, G: rotary stability.

difficult, the same method was used but the subject lifted the opposite arm and leg.[16] The scoring criteria are 3 points for deep squat, hurdle step, and inline lunge when the functional movement pattern was performed without issues, and 2 points when the functional movement pattern was performed but with compensatory movement.1 point was given when the functional movement pattern could not be performed, and 0 point was given when pain appeared in the movement pattern.[15] Shoulder mobility was awarded as 3 points when the distance between fists was within 1 hand length, 2 points when within 1.5 hand length, 1 point when 1.5 hand lengths or more, and 0 points when pain occurred during the task. Active straight leg raise was awarded 3 points if the lateral malleolus on the test side passed the midpoint of the anterior superior iliac spine and the knee joint, 2 points if it did not pass the midpoint, and 1 point if it did not pass the knee joint. 0 points were awarded when pain occurred during the task. Trunk stability push-up was awarded 3 points if the hands were level with the forehead and all the criteria were met, 2 points if the hands were level with the chin, and 1 point if this movement was not possible. 0 points were awarded when pain occurred during the task. Rotary stability was awarded 3 points if the subject were able to lift the arm and leg on the same side, 2 points if only the contralateral arm and leg, and 1 point if this movement could not be performed. 0 points were awarded when pain occurred during the task.[16] Furthermore, the number of people scoring less than 14/21 for the total FMS score as a secondary outcome.[9,12] For balance ability, single leg stance time on the dominant leg side (pitching leg forward) was measured with the eyes closed. During this test, the hip and knee on the non-weight-bearing side were positioned at 90° flexion. The subject was barefooted, with hands resting on hips. The time to failure to hold this position was repeated twice with the maximum value recorded. Fatigue in the previous week was measured on an 11-point numerical rating scale (NRS) anchored at 0 as no fatigue and 10 maximum possible level of fatigue. Pitching ball speed and control were used to evaluate baseball performance using each player's preferred method of pitching. The pitching protocol was set to 3 and 20 fastball pitches at maximum effort toward the simulated strike zone at the official distance of 18.44 m. We recorded the fastest ball velocity from 3 pitches using a speed gun (SR3600; Sports Radar Ltd, Homosassa, FL). The number of strikes out of the 20 pitches and pitches that were less than 70% of the maximum speed were not included. Measurement was taken after the participants performed a preparation routine of stretching and warm-up throwing. One trained physiotherapist (KS) measured all items to reduce measurement bias.

2.4. Intervention

In the control group, all players practiced as usual and there was no limit on voluntary baseball training. In the intervention group, FMS training for tasks that were scored at 2 points or less in the FMS was carried out 4 times per week for 12 weeks from September 2017 to November 2017. Following this, normal activity resumed without FMS training for a further 12 weeks period. FMS training took place after practice and before cool down, taking 15 minutes per session. Due to the lack of specialized equipment in the high-school environment, we adopted training that could be implemented with simple equipment such as towels, cushions, and sticks as used in previous studies,[13,14] and according to the official website of FMS.[20] The training was set based on the result of each player's FMS score (Table 1). In addition, the researcher demonstrated the FMS training program using a video recording. Players were asked to record relevant data daily during the investigation. In addition, a representative elected at each high school was tasked to ensure that data was properly recorded. This person checked the implementation of the exercise protocol at least once every 2 weeks. The compliance rate was calculated based on actual and scheduled FMS training implementation days as a secondary

Table 1

The FMS training contents decided by low Functional Movement Screen score in intervention group.

FMS	Deep squat	Hurdle step	Inline lunge	Shoulder mobility	Active straight leg raise	Trunk stability push-up	Rotary stability
FMS training	Toe touch progression	Table top stride flexor stretch	Dip cycle	Full bow stretch	Toe touch progression	Trunk rotation	Trunk stability
	Toe touch squat	Hip stretch	Dowel twist	Prone press up	Active Leg Lowering to Bolster	Side plank knee	T-Spine Rotation with Reach
	Deep squat	Double leg stretch	Brettzel	Quadruped T-Spine Rotation Lumbar Locked	Trunk rotation	Side plank	Quadruped T-Spine Rotation Lumbar Locked
	Brettzel	Mountain climber	Bridge advance	T-Spine Rotation with Reach	Half kneeling rotation	Push up shoulder tap	Wall sit bilateral reach
	Full bow stretch	Leg lock bridge	Dorsiflexion from Half Kneeling with Dowel	Wall sit bilateral reach	Leg lock bridge		
	Prone press up	Brettzel					
	Wall sit bilateral reach	Bridge advance					
	Dorsiflexion from Half Kneeling with Dowel	Table top stride with rotation					

outcome. All physical function assessments were performed by the research team and the measurers were blinded.

2.5. Statistical analysis

Data were analyzed with SPSS version 25.0 (IBM Japan, Tokyo, Japan). Unpaired t tests were used to compare characteristics between the intervention and control groups. Dunnett test was performed for intragroup comparison of each group; data at 8, 12, and 24 weeks with data before the intervention. Mann–Whitney U tests were used to compare FMS scores, single leg stance time, fatigue in the previous week, pitching ball speed, and control between the intervention and control group prior to the intervention, as well as at 8, 12, and 24 weeks following the intervention. χ^2 tests were used to compare subjects with FMS scores less than 14/21 between the intervention and control groups at each time point. Significance was set at a level of $P<.05$.

2.6. Ethics

Approval to participate in this research was sought from the principal and coach of each high school. All players were provided with written information about the research prior to obtaining consent. After confirming that they understood the research, approval was sought from the player's parents with a signed consent form. The study was approved by our institutional review board, the Ethics Committee at the Faculty of Health and Medical Care, Saitama Medical University, Japan (M-75). Registered as a trial registration at the University hospital Medical Information Network Center, Tokyo, Japan. (UMIN000027553).

3. Results

A total of 71 baseball players aged 15 to 17 years were recruited from 4 high schools in Saitama, Japan and were randomly assigned to either an intervention group (n = 37) or control group (n = 34) from April 2017 to June 2017 (Fig. 2). The allocation was not concealed. There was no significant difference in the characteristics of participants and FMS score between the 2 groups (Tables 2 and 3). There were no missing data for all items in this study. There were no serious adverse effects. This study had to be done during the off-season because baseball games affect the amount of individual practice. However, the number of people who consented to take part did not recruit. Since the number of participants was less than planned, we conducted a post hoc power analysis.

3.1. FMS score

Comparison for intragroup of each group and between groups is shown in Table 3. Total FMS score and active straight leg raise significantly increased in both the groups after 8, 12, and 24 weeks. Most items of FMS score improved significantly after 8 and 12 weeks of intervention: deep squat, hurdle step, inline lunge, trunk stability push-up, and rotary stability. In comparison between groups, in the intervention group (n = 37) compared with the control group (n = 34) after 8 weeks intervention evaluation point, the following variables significantly higher than items in the control group: deep squat ($P=.009$, $1-\beta=0.78$), hurdle step ($P<.001$, $1-\beta=0.99$), inline lunge ($P=.008$, $1-\beta=0.57$), active straight leg raise ($P=.013$, $1-\beta=0.70$), trunk stability push-up ($P<.001$, $1-\beta=0.99$), rotary stability ($P=.015$, $1-\beta=0.61$). Total FMS score in the intervention group was significantly higher than one in the control group after 8 weeks intervention evaluation point ($P<.001$, $1-\beta=0.99$).

Additionally, FMS scores in the intervention group were significantly higher than ones in the control group after 12 weeks intervention evaluation point: hurdle step ($P<.001$, $1-\beta=0.99$), inline lunge ($P=.001$, $1-\beta=0.97$), active straight leg raise ($P=.006$, $1-\beta=0.88$), trunk stability push-up ($P=.001$, $1-\beta=0.98$), total FMS score ($P<.001$, $1-\beta=0.99$). At the 24 weeks evaluation point, there was no significant between group difference in FMS score.

Shoulder mobility was not shown to be significantly different between groups at any time point.

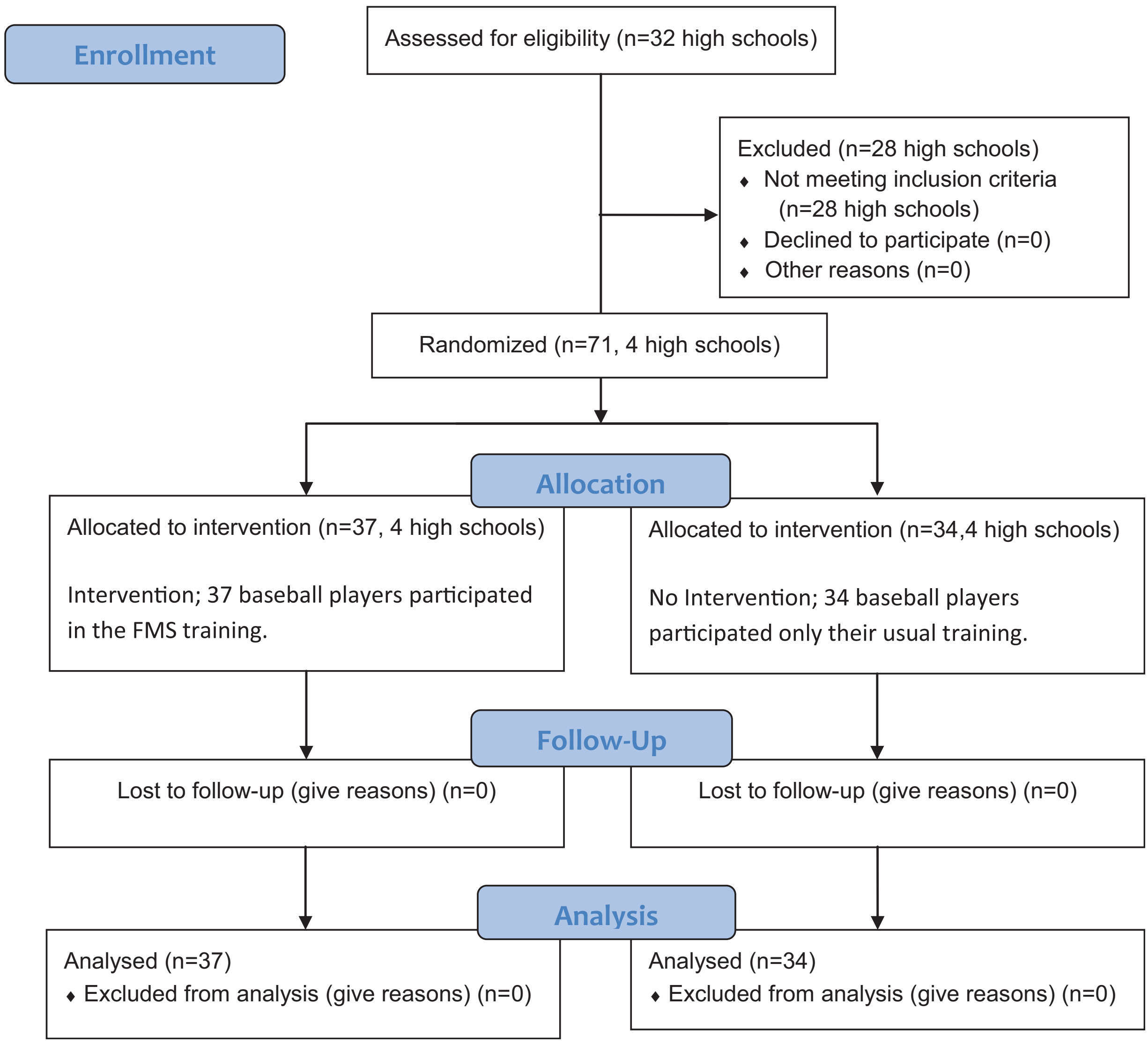

Figure 2. Enrollment flow diagram.

3.2. Physical function and baseball performance

Comparisons for intragroup of each group and between groups are shown in Table 4. Pitching ball control in the intervention group was significantly lower compared with control group. Single leg stance time significantly increased in both the groups after 24 weeks. Pitching ball speed in the intervention group

Table 2

Characteristics of participants (n = 71).

		Intervention (n = 37)	Control (n = 34)	*P*
Age (yr)		16.0 ± 0.1 (15–17)	15.8 ± 0.1 (15–17)	.17
Height (cm)		169.3 ± 0.9 (156–181)	169.7 ± 1.0 (158.6–179)	.76
Body weight (kg)		63.5 ± 1.4 (41–43)	62.1 ± 1.2 (49–80)	.41
Experience as a baseball player (years)		7.7 ± 0.3 (2–10)	7.3 ± 0.3 (3–10)	.37
Dominant hand (n)	Right/left	34/3	28/6	.29
Position (n)	Pitcher	6	9	.38
	Catcher	3	4	.70
	Infielder	16	14	>.99
	Outfielder	12	7	.29

Mean ± SD (in-max).

Table 3

Functional Movement Screen score before and after the intervention period in the intervention and control group.

	Group	Prior to the intervention	After 8 weeks	After 12 weeks	After 24 weeks
Total FMS score	Intervention	13.72 ± 2.57 (8–18)	17.66 ± 1.72 (12–20)*,†	17.49 ± 1.48 (13–20)*,†	15.34 ± 2.34 (9–19)†
	Control	13.82 ± 2.72 (8–18)	15.07 ± 2.56 (9–18)†	14.74 ± 2.31 (9–18)†	15.52 ± 1.63 (12–18)†
Deep squat	Intervention	2 (0–3)	2 (2–3)*,†	2 (2–3)†	2 (1–3)
	Control	2 (0–3)	2 (0–3)	2 (0–3)	2 (0–3)
Hurdle step	Intervention	3 (1–3)	3 (1–3)*,†	3 (1–3)*,†	2 (1–3)
	Control	2 (1–3)	2 (1–3)	2 (1–3)	2 (1–3)
Inline lunge	Intervention	3 (1–3)	3 (1–3)*,†	3 (2–3)*,†	3 (1–3)
	Control	3 (0–3)	3 (1–3)	2.5 (1–3)	2 (1–3)
Shoulder mobility	Intervention	3 (1–3)	3 (1–3)	3 (1–3)	3 (1–3)
	Control	3 (1–3)	3 (1–3)	3 (1–3)	3 (1–3)
Active straight leg raise	Intervention	2 (1–3)	2 (2–3)*,†	2 (2–3)*,†	2 (1–3)†
	Control	2 (1–3)	2 (1–3)†	2 (0–3)†	2 (1–3)†
Trunk stability push up	Intervention	2 (0–3)	3 (1–3)*,†	3 (2–3)*,†	2 (0–3)
	Control	2 (0–3)	2 (1–3)	2 (1–3)	2 (1–3)
Rotary stability	Intervention	2 (0–3)	2 (2–3)*,†	2 (2–2)†	2 (1–3)
	Control	2 (1–2)	2 (1–2)†	2 (1–2)†	2 (1–2)

Total FMS score; mean ± SD (min-max).
Deep squat, Hurdle step, Inline lunge, Shoulder mobility, Active straight leg raise, Trunk stability push up, Rotary stability; median (min-max).
FMS = functional movement screen.
* There is a significant difference at the same time compared with the control group ($P < .05$).
† Data are significantly larger than data before the intervention ($P < .05$).

compared with control group was significantly decreased after 12 weeks. Pitching ball control in the intervention group was significantly improved after 8, 12, and 24 weeks. In comparison between groups, single leg stance time in the intervention group was significantly higher than one in the control group at the 8 weeks evaluation point ($P = .008$, $1-\beta = 0.55$), which was also the case at the 12 weeks evaluation point ($P = .013$, $1-\beta = 0.59$). In contrast, pitching ball speed in the intervention group was significantly lower than the one in the control group ($P = .046$, $1-\beta = 0.17$). At the 24 weeks evaluation point, single leg stance time was significantly higher ($P = .022$, $1-\beta = 0.59$) and feeling of fatigue was significantly lower ($P = .004$, $1-\beta = 0.77$) than the one in the control group.

Pitching ball control was not shown to be significantly different between groups at any time point.

3.3. Subjects scoring less than 14/21 for the total FMS score

The number of subjects who scored less than 14/21 for the total FMS score significantly decreased after 8 weeks of the intervention ($P = .005$, $1-\beta = 0.71$) and after 12 weeks ($P = .039$, $1-\beta = 0.71$), respectively ($P < .05$) (Table 5).

Table 4

Physical function and baseball performance before and after the intervention period in the intervention and control group.

	Group	Prior to the intervention	After 8 weeks	After 12 weeks	After 24 weeks
Single leg stance time (s)	Intervention	25.70 ± 25.22 (2.1–120)	27.55 ± 23.10 (3–77)*	39.13 ± 41.91 (5–188)*	40.92 ± 29.98 (4.1–103.2)*,†
	Control	19.44 ± 17.68 (2–77)	16.01 ± 19.18 (1.6–81)	20.95 ± 22.63 (2.1–120.2)	22.76 ± 20.50 (3.3–75.3)†
Fatigue (NRS)	Intervention	6 (3–10)	7 (3–9)	5 (1–10)	5 (2–10)*
	Control	7 (2–9)	7 (3–10)	5 (1–10)	7 (2–10)
Ball speed (mile/h)	Intervention	65.67 ± 5.49 (55–81)	64.9 ± 6.29 (55–77)	64.83 ± 5.53 (57–78)*,†	67.55 ± 5.60 (54–78)
	Control	65.29 ± 4.82 (56–75)	64.25 ± 4.28 (55–73)	66.11 ± 4.43 (58–77)	66.79 ± 4.84 (59–78)
Ball control	Intervention	6.80 ± 2.58 (2–13)*	9.00 ± 2.79 (3–17)†	8.60 ± 2.42 (3–13)†	8.50 ± 2.81 (1–12)†
	Control	8.35 ± 2.93 (2–13)	9.27 ± 2.45 (5–14)	8.71 ± 2.94 (4–14)	9.71 ± 2.84 (3–16)

Single leg stance time, Ball speed, Ball control; mean ± SD (min-max), Fatigue: median (min-max).
NRS = numerical rating scale.
* There is a significant difference at the same time compared with the control group ($P < .05$).
† There is a significant difference compared with data before the intervention ($P < .05$).

Table 5

Number of people with Functional Movement Screen score less than 14 at each time.

Group	Prior to the intervention	After 8 weeks intervention	After 12 weeks intervention	After 24 weeks intervention
Intervention (n)	18 (37)	1 (33)*	3 (37)*	5 (34)
Control (n)	14 (34)	9 (32)	9 (34)	6 (33)

* χ^2 test. Significant difference compared with the control group ($P < .05$).

3.4. Compliance with FMS training

Compliance with FMS training was 100% during the 12 weeks intervention period in the 37 subjects in the intervention group.

4. Discussion

Intragroup comparisons showed that most FMS scores improved to 12 weeks after continued training. In comparison between groups, an FMS training program led to a significantly high score after 8 weeks in deep squat, hurdle step, inline lunge, active straight leg raise, trunk stability push-up and rotary stability FMS score, as well as total FMS score. After 12 weeks training, hurdle step, inline lunge, active straight leg raise, trunk stability push-up, and total FMS score again had significantly higher than one in the control group. The number of subjects who scored less than 14 for the total FMS score in the intervention group compared to control group were significantly less after 8 and 12 weeks of training.

Deep squat, hurdle step, inline lunge, trunk stability push-up, rotary stability, and total FMS score improved after 8 weeks training. Consistent with our results, Bodden[7] reported that the total FMS score improved with FMS training after 4 and 8 weeks in mixed martial arts athletes. However, we found that the improved FMS scores in high-school baseball players returned to their original level after 12 weeks after ceasing training. Therefore, it is proposed that athletes need to continue FMS training to maintain improvements gained. The hurdle step requires dorsiflexion of the ankle in an open kinetic chain and flexion of the hip and knee joints.[15] Janicki[21] suggest that although hip and ankle ROM does not have a strong relationship with FMS hurdle step scores, they are a contributing factor. Closed kinetic chain training within FMS exercises is likely to improve proprioception, which is necessary for smooth movement.[22] Proprioception also improves accuracy with movement.[23] The inline lunge test evaluates hip and ankle mobility and stability, quadriceps flexibility, and knee stability.[15] Dinc[19] reported that the inline lunge score improved by performing upper and lower extremity stretching, trunk muscle training, and functional movement training. The active straight leg raise mainly evaluates the flexibility of the lower extremity and core stability with lower extremity movement.[16,24] Previous studies have reported that stretching using a foam roller is useful for improving hip ROM.[25] On the other hand, trunk stability push-up requires symmetrical trunk stability in the sagittal plane during a symmetrical upper extremity movement. Poor performance during this test could be attributed to poor stability of the trunk stabilizers.[16] In comparison between groups, deep squat and rotary stability were higher than ones in the control group after 8 weeks of training. Deep squat mainly evaluates dorsiflexion of the ankles, flexion of the knees and hips, extension of the thoracic spine, and flexion and abduction of the shoulders in closed kinetic chain.[15] Rotary stability evaluates asymmetric trunk stability in both the sagittal and transverse planes during asymmetric upper and lower extremity movement. Poor performance during this test can be attributed to insufficient stability of the trunk stabilizers.[16] However, most FMS scores improved to 12 weeks after continuous training and showed no significant improvement with follow-up.

It has been reported that the number of professional football players with an FMS score greater than 14 increased from 7 to 30 athletes after FMS training.[13] Some studies had reported that the injury risk when below 14 points increased 11-fold in professional football players for 4.5 months post evaluation[12] and 15-fold in college athletes throughout the season.[11] In our study, the number of people with less than 14 points significantly decreased in the intervention group after 8 and 12 weeks of FMS training, but there was no significant difference after 12 weeks after training ceased. This would suggest that continued FMS training is necessary to exceed the cut-off value. If the training is not continued, it is likely that the training effect will dissipate and the player will return to the original ability level.

The limitations of this study were that training was performed on items with low scores confirmed by FMS. No attempt was made to identify why individuals had poor control on FMS tests. Future studies might investigate why individuals have poor control, hence a more specific evaluation-based approach. Second, the number of subjects did not reach the target number provisionally calculated. However, a post hoc power analysis using the sample size obtained, the $1-\beta$ value was 0.99 in the total FMS score at 8 and 12 weeks evaluation point. Hence the sample size was adequate. Third, group allocation was not concealed. Finally, our study shows that FMS training improves FMS scores, but it does not indicate how long training should be continued, future studies might consider this. Furthermore, in this study, we adapted training using towels, cushions, and sticks. This might have influenced the results.

5. Conclusion

We evaluated the effect of FMS training in adolescent baseball players. FMS training for 8 weeks improved the FMS score and single leg stance time. If the training is not continued, it is likely that the training effect will dissipate. Additionally, the number of people below the 14 points total FMS cut-off score decreased following training.

Acknowledgment

The authors thank the players, parents, principal, and coaches for their assistance to this study.

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