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Comparison of the Effect of Sportsmetrics Soccer Training on Movement Performance in Soccer Players with and without Anterior Cruciate Ligament Reconstruction

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SUMMARY

Objective. The purpose of this study was to compare the effect of Sportsmetrics soccer training (SMST) on the scores of Functional movement screening (FMS) test items in soccer players with and without reconstruction of the anterior cruciate ligament (ACLR).

Materials and methods. The method of this study was a quasi-experimental type, and the number of statistical samples that participated in the present study included 42 soccer players. They were divided into two groups of 21 (with ACLR and without ACLR). The FMS test was evaluated in both groups before and after six weeks of SMST training. To analyze the research data in intra-group differences, a dependent t-test was used, and for inter-group differences, an analysis of covariance test was used ($p \leq 0.05$).

Results. After six weeks of SMST training, a comparison of the mean pre-test and post-test scores of all items and the total score of the FMS test in both groups, showed a significant difference ($p \leq 0.05$). However, no significant difference was observed in the results between the two groups in the items and the total score of the FMS test after six weeks of SMST training ($p \geq 0.05$).

Conclusions. In addition to predicting the probability of injury, it is suggested that the FMS test be used to evaluate the impact of various training on the probability of injury. The application of SMST training for soccer players with and without ACLR is also suggested, as it can help to reduce the risk of injury in soccer players.

KEY WORDS

ACL injury; functional movement screen; injury prevention; soccer; sportsmetrics.

INTRODUCTION

Soccer is one of the most popular and attractive sports in the world (1). With the increasing popularity of this sport and the rapid growth in the number of participants in this field, the prevalence of sports injuries in this field is also increasing (2). On the other hand, because soccer involves physical encounters, there is a possibility of injury regardless of age and gender. 66% of soccer injuries occur in the lower limbs, with the ankle and knee being the most common injury sites (3). ACL tear is one of the most severe and complicated knee injuries. This injury often leads to reduced performance, extended absence from training sessions, laxity of the knee joint, proprioception disorder, and premature osteoarthritis (4). Post-traumatic financial issues such as the cost of surgery, rehabilitation, and psychological factors have highlighted the need to use injury prevention programs (5).

Prevention of injuries has been one of the major soccer issues in recent years (6). Overall, prevention protocols can be divided into two main groups: neuromuscular training and special warm-up (7). Neuromuscular training is considered the best and most effective way to prevent injury and improve performance techniques (8). Alentorn-Geli *et al.* (9) concluded that multi-component prevention programs have better results in ACL injury prevention compared to single-component programs. In this context, the SMST protocol has specialized in preventing injuries and enhancing the performance of soccer players (10). SMST offers a variety of training methods that have been used with preventive goals and improving the performance of athletes in previous research (4). For example, Noyes *et al*. (4) observed a significant increase in the performance of female soccer players by combining the general warm-up program and specialized SMST training.

On the other hand, movement assessment allows health and physical fitness professionals to develop an injury prevention model by observing movement defects and muscle imbalances, as well as using deformed muscles and the scores of functional movement screening (FMS) tests to predict lower limb injuries in athletes (11). Screening is done to prevent injuries and improve implementation strategies. FMS tests include seven movement tests that can detect limitations and changes in normal movement patterns. These tests are designed to assess the interaction between the mobility of the movement chain and the stability required to execute functional and essential movement patterns (12). The maximum score in this test is 21, and a score below 14, according to research, indicates a person's susceptibility to injury (13). FMS tests can assess the quality of performance patterns and identify individuals at risk of injury, making them a useful method for injury identification and prevention (14).

Many studies have reported the positive effect of SMST training on injury reduction. However, no studies have been found that measured the effect of this training on the FMS tests in soccer players with ACLR. Additionally, very limited research has been done on the effect of injury prevention training on the FMS test items in order to overcome the discrepancies of previous research. Hence, it seems essential to examine different items of the FMS test using the training that has already been proven effective. Therefore, the aim of the present study was to compare the evaluation of the FMS test items using a period of SMST training in soccer players with and without ACLR.

MATERIALS AND METHODS

This quasi-experimental study was conducted with a pre-test-post-test design. The statistical population consisted of soccer players from the Premier League and First Division in two countries. These players had at least three years of team training experience in soccer and were between the ages of 18 and 30. This age range was chosen to remove the initial effects of training. Based on previous papers and the use of G Power software, it was determined that a minimum of 42 subjects were needed to achieve a statistical power of 0.8, a reliability coefficient of 0.8, and a significance level of 0.05. From the statistical population, 42 cases were selected as a statistical sample using purposive and accessible sampling. These cases were then randomly divided into two groups: experimental (n = 21 with ACLR) and control (n = 21 without ACLR). Inclusion criteria included 3-5 years of experience in teamwork and training at the club level of soccer. The subjects in the ACLR groups were undergoing ACL reconstruction. They should have no history of diseases associated with poor balance, a body mass index in the normal range, and no injuries in the lower limb other than ACL in the last 6 months. They should also have no obvious abnormalities in the lower limbs (anteversion, genu valgum, genu varum, tibial torsion, and flat foot) as determined by the New York test. Additionally, no less than 6 and no more than 24 months should have passed since ACL reconstruction. Exclusion criteria included non-participation in more than three sessions or two consecutive sessions of the SMST knee injury prevention program. Subjects who experienced pain or discomfort during training, suffered an injury during training, or withdrew from the study were also excluded (4). Taking into consideration the ethical considerations of the study, such as the confidentiality of the subjects' information, the use of an experienced instructor and examiner to prevent any possible injury, giving full authority to the subjects to leave the research at any stage, and explaining the purpose of the research to all the subjects before starting the exercises and signing the consent form to participate in the research. The present study was approved by the ethics committee of the Iranian Research Institute of Physical Education and Sport Sciences with IR.SSRC.REC.1402.093 code – date of approval: August 07, 2023).

Functional Movement Screen (FMS) test

FMS was used to test the values of pre- and post-test, before and after the training period, according to Cook's *et al*. instructions. The FMS tests are composed of seven performance tests, which include deep squat, hurdle step, in-line lunge, shoulder mobility, trunk stability, active straight leg rise, and rotary stability (**figure 1**). The scoring for each test ranges from 0 to 3. The scoring for the FMS™ consists of four discrete possibilities (13, 15). The scores range from zero to three, with three being the best possible score. An individual is given a score of zero if they experience pain anywhere in the body during the testing. If pain occurs, a score of zero is given and the painful area is noted. If the patient does not score a zero, a score of one is given if they are unable to complete the movement pattern or assume the position to perform the movement. A score of two is given if the person is able to complete the movement but must compensate in some way to perform the fundamental movement. A score of three is given if the person performs the movement correctly without any compensation, complying with standard movement expectations associated with each test. After completing all seven tests, the scores are added together and considered as the individual's overall FMS score. Subjects can get a grade between zero and 21, which, according to previous reports, a score less than 14 can be indicative of the probability of injury (16). FMS test scores were determined by observation of videos recorded by two cameras from the front and side views during the implementation of FMS tests.

Figure 1. Seven tests from the Functional Movement Screen.

Sportsmetrics Soccer Training

The SMST protocol has several basic parts that are essential for the performance of soccer players. It consists of four training components: agility and reaction, speed and endurance, plyometric, and strength. This protocol is designed in a way that soccer players engage in new exercises for each section every week, while the nature of the training sections remains the same. It is tailored to the specific requirements of each training section. The necessary tools for performing the exercises include cones and training funnels, resistance therabands, ladders, and Pilates bands. The training program varied each week, and at the beginning of each week, the entire weekly program was taught. Both groups received theoretical instruction on the entire weekly program at the start of each week. The duration of each session in the protocol ranged from 60 to 90 minutes. Both groups underwent sportsmetrics training (**table I**). The training took place during the bodybuilding season and before the competition.

Statistical analyses

After collecting data, descriptive statistics were used to calculate the mean and standard deviation of height, weight, age, and body mass index (BMI). The normality of data distribution was evaluated using the Shapiro-Wilk test. A dependent t-test was used for intragroup comparison, and an analysis of One-Way ANOVA test was used for comparison between two groups with and without ACLR in pre-test and post-test. Statistical calculations were performed using SPSS ver.27 software with a significance level of $p \leq 0.05$.

RESULTS

The mean and standard deviation of the demographic characteristics of the subjects are reported in **table II**.

For intra-group comparisons, a dependent t-test was used. The results of the ACLR group in **table III** and the results of the group without ACLR were reported in **table IV**.

The results of **table III** show that there is a significant difference between the values of all items and the overall score of the FMS test after 6 weeks of SMST training in the pre-test and post-test in the group with ACLR. We observe an improvement in the average of these items and the overall score.

The results of **table IV** show that there is a significant difference between the values of all items and the overall score of the FMS test after 6 weeks of SMST training in the pre-test and post-test in the group without ACLR. We observe an improvement in the average of these items and the overall score.

The results of **table V** indicated that there was a significant difference between the records of the Deep Squat ($p = 0.03$), Hurdle Step ($p = 0.03$), In-Line Lunge ($p = 0.01$), Shoulder Mobility ($p = 0.04$), Rotatory Stability ($p = 0.01$), Active Straight Leg Rise ($p = 0.03$), Trunk Stability ($p = 0.03$), and Total ($p = 0.01$) in the pre-test of two groups with and without ACLR after 6 weeks of SMST training.

The results of **table VI** indicated that there was no significant difference between the record of the Deep Squat ($p = 0.31$), Hurdle Step ($p = 0.54$), In-Line Lunge ($p = 0.76$), Shoulder Mobility ($p = 0.56$), Rotatory Stability ($p = 0.47$), Active Straight Leg Rise ($p = 0.80$), Trunk Stability ($p = 0.78$), and Total ($p = 0.78$) in the post-test of two groups with and without ACLR after 6 weeks of SMST training.

Table I. Sportsmetrics soccer training program (4).

Week (Sessions)	Jump Training	Agility, Reaction	Acceleration, Aerobic, Endurance	Ladders-Quick Feet, Dot Jump Drills
Week 1 (1-3)	Wall jump (20 s); tuck jump (20 s); squat jump (10 s); barrier jumps (20 s each); side-to-side; forward backward; 180 jump (20 s); broad jump (5 repetitions); bounding in place (20 s)	Serpentine run ¼ field (3 repetitions); wheel drill: listen to the instructor, 30 s, 2 repetitions	Partner push offs, hold 5 s, 5 repetitions (sprint to 10-yd line and back); sprint-backpedal, ½ field or 50 yd, 5 repetitions; 4 laps around the field (1280 yd)	Ladder: up-up and back-back, 2 repetitions; dot drill: double leg jumps, 5 repetitions × 3
Week 2 (4-6)	Same as sessions 1–3; add 5 s to each jump; add 5 repetitions to broad jump	Modified shuttle ¼ field, 3 repetitions; sprint-stop feet listen, 30 s, 2 repetitions	Acceleration with a band (to 10-yd line); sprint with ground touches backpedal, ½ field or 50 yd, 5 repetitions; 100-yd shuttle: 3 × 100 (300 yd), 4 repetitions	Ladders: toe touches, 2 repetitions; dot drills: add split leg jumps, 5 repetitions × 3
Week 3 (7-9)	Wall jump (25 s); tuck jump (25 s); triple broad into vertical jump (5 repetitions); squat jump (15 s); barrier hops (25 s each); side-to-side; forward-backward; single-leg hop (5 repetitions); scissors jump (25 s); bounding for distance (1 run)	Square drill, 30’ × 30’ box, 2 repetitions; sprint quick feet-listen, 45 s, 2 repetitions	Partner push offs, hold 10 s; 5 repetitions (sprint to 10-yd line and back); ¼ eagle, instructor cued, into sprint, jog back, ½ field or 50 yd, 6 repetitions; 50-yd shuttle: up and back 3 × 100 (300 yd), 4 repetitions	Ladders: outside foot in, 2 repetitions; dot drills: add 180 split leg jump, 5 repetitions × 3
Week 4 (10-12)	Same as sessions 7-9; add 5 s to each jump; add 3 repetitions to triple broad into vertical jump	Nebraska drill, 30’ long, 4 repetitions; reaction drill-watch instructor point, 45 s, 2 repetitions	Acceleration with band (to 20-yd line); box drill, sprint-90-backpedal, ½ field, 3 repetitions; 50-yd cone drill: 10 y-back, 20 y-back, 30 y-back, 40 y-back, 50 y-back; 4 repetitions	Ladders: in-in, out-out, 2 repetitions; dot drills: add single-leg hops, 5 repetitions
Week 5 (13-15)	Wall jump (20 s); step, jump up, down, vertical (30 s); squat jump (25 s); mattress jumps (30 s each); side-to-side; forward-backward; triple single-leg hop, stick; (5 repetitions each leg) jump into bounding (3 runs)	Illinois drill, 15’ × 10’, 4 repetitions; reaction mirror drill pressing, 60 s, 2 repetitions	Partner push offs, hold 15 s, 5 repetitions (sprint to 10-yd line and back); sprint-180-backpedal, jog back, ½ field or 50 yd, 7 repetitions; jingle jangle 20 yd, up and back × 5 (200 yd), 5 repetitions	Ladder: up-up and backback, 2 repetitions; dot drills: combo all jumps, 5 repetitions × 3
Week 6 (16-18)	Same as sessions 13-15; add 5 repetitions to step, jump up, down, vertical; add 1 run to jump into bounding	T-drill: 5-10-5, 4 repetitions; advanced wheel drill: listen to the instructor, 60 s, 2 repetitio	Acceleration with a band (to 30-yd line); sprint-360-sprint (jog back), ½ field or 50 yd, 7 repetitions; jingle jangle 10 yd, up and back × 5 (100 yd), 6 repetitions	Ladder: 1 foot forward, 1 foot backward (scissors), 2 repetitions; dot drills: combo all jumps, 5 repetitions

Table II. Demographic characteristics of the subjects.

Variable	Group	n	Mean ± SD
Age(y)	Experimental 1*	21	23.23 ± 2.30
	Experimental 2*	21	23.19 ± 2.24
Height (cm)	Experimental 1	21	179.66 ± 7.26
	Experimental 2	21	180.14 ± 4.43
Weight (kg)	Experimental 1	21	71.90 ± 8.33
	Experimental 2	21	71.52 ± 4.13
BMI (kg/m^2)	Experimental 1	21	22.13 ± 2.39
	Experimental 2	21	21.98 ± 1.04

*Experimental 1: with ACLR; Experimental 2: without ACLR.

Table III. The results of the dependent t-test in the group with ACLR.

FMS TEST	Mean ± SD Pre-test	Mean ± SD Post-test	t	p
Deep Squat	1.38 ± 0.49	2.23 ± 0.62	-6.85	0.01
Hurdle Step	1.71 ± 0.46	2.42 ± 0.50	-5.08	0.01
In-Line Lunge	1.23 ± 0.43	2.47 ± 0.51	-10.52	0.01
Shoulder Mobility	1.71 ± 0.56	2.61 ± 0.58	-6.63	0.01
Rotatory Stability	1.14 ± 0.35	2.09 ± 0.70	-6.52	0.01
Active Straight leg rise	1.33 ± 0.48	2.18 ± 0.49	-6.85	0.01
Trunk Stability	1.71 ± 0.56	2.47 ± 0.60	-6.47	0.01
Total	**10.23 ± 1.67**	**16.51 ± 2.88**	**-17.48**	**0.01**

Table IV. The results of the dependent t-test in the group without ACLR.

FMS TEST	Mean ± SD Pre-test	Mean ± SD Post-test	t	p
Deep Squat	1.95 ± 0.58	2.44 ± 0.56	-4.26	0.01
Hurdle Step	2.09 ± 0.30	2.52 ± 0.49	-3.87	0.01
In-Line Lunge	1.66 ± 0.57	2.42 ± 0.50	-8.00	0.01
Shoulder Mobility	2.23 ± 0.53	2.71 ± 0.26	-4.26	0.01
Rotatory Stability	1.47 ± 0.51	1.95 ± 0.74	-4.26	0.01
Active Straight leg rise	1.85 ± 0.57	2.23 ± 0.62	-3.50	0.02
Trunk Stability	2.19 ± 0.40	2.52 ± 0.51	-3.16	0.05
Total	**13.58 ± 2.10**	**16.82 ± 2.48**	**-12.20**	**0.01**

Table V. The results of the One-Way ANOVA analysis test for comparison between groups in the pre-test.

FMS TEST	Group	n	Mean ± SD Pre-test	p	F	Effect size
Deep Squat	Experimental 1	21	1.38 ± 0.49	0.03	9.86	0.39
	Experimental 2	21	1.95 ± 0.58			
Hurdle Step	Experimental 1	21	1.71 ± 0.46	0.03	10.00	0.39
	Experimental 2	21	2.09 ± 0.30			
In-Line Lunge	Experimental 1	21	1.23 ± 0.43	0.01	7.36	0.34
	Experimental 2	21	1.66 ± 0.57			
Shoulder Mobility	Experimental 1	21	1.71 ± 0.56	0.04	9.52	0.38
	Experimental 2	21	2.23 ± 0.53			
Rotatory Stability	Experimental 1	21	1.14 ± 0.35	0.01	5.97	0.32
	Experimental 2	21	1.47 ± 0.51			
Active Straight leg rise	Experimental 1	21	1.33 ± 0.48	0.03	10.25	0.39
	Experimental 2	21	1.85 ± 0.57			
Trunk Stability	Experimental 1	21	1.71 ± 0.56	0.03	10.00	0.39
	Experimental 2	21	2.19 ± 0.40			
Total	**Experimental 1**	**21**	**10.23 ± 1.67**	**0.01**	**32.13**	**0.60**
	Experimental 2	**21**	**13.58 ± 2.10**			

Table VI. The results of the One-Way ANOVA analysis test for comparison between groups in the post-test.

FMS TEST	Group	n	Mean ± SD Post-test	p	F	Effect size
Deep Squat	Experimental 1	21	2.23 ± 0.62	0.31	1.01	0.17
	Experimental 2	21	2.44 ± 0.56			
Hurdle Step	Experimental 1	21	2.42 ± 0.50	0.54	0.36	0.13
	Experimental 2	21	2.52 ± 0.49			
In-Line Lunge	Experimental 1	21	2.47 ± 0.51	0.76	0.09	0.09
	Experimental 2	21	2.42 ± 0.50			
Shoulder Mobility	Experimental 1	21	2.61 ± 0.58	0.56	0.33	0.13
	Experimental 2	21	2.71 ± 0.26			
Rotatory Stability	Experimental 1	21	2.09 ± 0.70	0.47	0.51	0.09
	Experimental 2	21	1.95 ± 0.74			
Active Straight leg rise	Experimental 1	21	2.18 ± 0.49	0.80	0.06	0.09
	Experimental 2	21	2.23 ± 0.62			
Trunk Stability	Experimental 1	21	2.47 ± 0.60	0.78	0.07	0.32
	Experimental 2	21	2.52 ± 0.51			
Total	**Experimental 1**	**21**	**16.51 ± 2.88**	**0.71**	**0.13**	**0.10**
	Experimental 2	**21**	**16.82 ± 2.48**			

DISCUSSION

The results show the effect of the SMST protocol on all items and the overall score of the FMS test in both groups of soccer players with and without ACLR. In the review of individual items, the results of the research showed that in all items in both groups with and without ACLR, we have seen an increase in the score, even to a very small amount. Although in the pre-test we saw a significant difference between the items and the overall score of the FMS test in the comparison between the two groups, there was no significant difference in the post-test after 6 weeks of SMST protocol exercises. This result indicates that the players who had a history of ACLR, although in the pre-test they had a weaker performance in the scores of the FMS test on average than the group without ACLR, but in the post-test this difference was not significant. This shows the positive effect of the SMST protocol in players with ACLR. In fact, according to the results of the current research, the SMST protocol can guarantee the return to sports with a high level of performance in players with a history of ACLR by influencing the movement patterns evaluated by the FMS test.

Unlike traditional muscle strength programs, during functional training, muscles are trained in three planes of movement, challenging the brain and body simultaneously. Indeed, intervention programs targeting multiple planes of movement are needed to reduce the effective risk of ACL injury (17). While regular muscle strength programs usually work on the sagittal or coronal plane, functional training also works on the transverse plane, where ACL injuries usually occur (18). One of the objectives of our protocol was to prevent ACL injury mechanisms: adduction and internal rotation of the hip, knee valgus, external rotation and anterior translation of the tibia, and eversion of the ankle (19, 20). The goal of functional training is to create a balance between agonist and antagonist muscles. Therefore, quadriceps dominance, which can increase the stress levels on the ACL and make it prone to injury, is modified by dynamic neuromuscular training (21, 22).

FMS test is one of the most widely used performance assessment methods used both in the medical and sport world (23, 24). FMS test is considered as a screening tool to determine the ineffectiveness of an individual's movement, an additional assessment to determine the dynamic and functional capacity, as well as to prepare for a return to play after rehabilitation from injury or surgery (25). It is believed that the FMS, alongside isokinetic muscle testing and injury risk assessment questionnaires, is one of the most popular systems for detecting injury predisposing factors among professional soccer players (26). McCall *et al.* analyzed the practice of medical staff of some of the world's top soccer clubs, showing that almost 66% of them use the above three methods to assess injury risk (27). In soccer, three of the most important risk factors for non-contact injuries are previous injury, fatigue, and muscle imbalance. FMS is the most common screening tool used to identify these factors and predict the risk of injury in Premier League teams (27). In this regard, Letafatkar *et al.*, based on the relationship between the injury history and FMS scores, reported that the FMS tests provided positive information in predicting the injury (14).

In our research, we selected FMS scores to assess study groups because it analyzes the whole body together. This test helps to identify defects in mobility, stability, and neuromuscular coordination. Muscle strength, flexibility, range of motion, coordination, balance, and proprioception are required to successfully complete the seven basic movement patterns. Kiesel *et al.* (28) noted that a low FMS score is a proven risk factor for injury in professional soccer players. Bonazza *et al.* (25) concluded that individuals with a score ≤ 14 on the FMS score are more than twice as likely to be at risk for musculoskeletal injury as those with a score ≥ 14. Therefore, according to our results of FMS scores, the SMST protocol can be a new tool to support the promotion of a safe return to sports activities after ACLR.

In the literature review of research, we can find a number of studies that have evaluated the effect of a particular type of training on FMS items. Papież *et al.* (29) conducted a study of a similar nature to the research we presented. They evaluated the impact of corrective activities on the FMS test items and compared a group of soccer players to players who were only engaging in recreational physical activity. Similar to our findings, they also reported improved scores after performing functional rehabilitation exercises. Therefore, they were able to show that providing FMS-based reforms in regular soccer training could significantly improve athletes' performance and reduce the risk of injury. Campa *et al.* (30) also reached similar results in a study on a group of soccer players belonging to the top four Italian youth clubs. After a 20-week corrective exercise cycle, soccer players significantly improved their overall FMS test score. In fact, researchers were able to prove that the measures taken will definitely affect the results of the experiments, thus reducing asymmetry and movement pattern impairment. Baron *et al.* (31) also conducted a study on young soccer players competing in the junior league. The purpose of their research was to evaluate the functional and physical parameters in order to choose a suitable process to improve these parameters. However, unlike our study, they only focused on three items of the FMS test (deep squat, hurdle step, and lunge). Additionally, they evaluated the speed tests. In the assessment done before the training program, the athletes had weaker performance in the above three items of the FMS test compared to our own research. However, after the completion of the functional training cycle, significant changes in the FMS test scores were observed among the evaluated players, which were similar to the results of our study. However, one can also find research in literature that does not support FMS test-based improvement. For example, Dossa *et al.* (32) stated that the FMS test could not be used in the preseason as a method for assessing the risk of injury in an ice hockey team. In addition, a study by Dorrell *et al.* confirmed low diagnostic reliability of this test to assess the risk of injury (21). However, in the present study, the effect of SMST on improving FMS items in both groups was significant.

Overall, the investigation had previously examined the impact of SMST on athletes without defects and concluded that SMST was a successful protocol in this category (33). However, studies of the impact of SMST on athletes with neuromuscular defects and those who had ACLR were unclear and extremely limited. Furthermore, it has been shown that the previous experience of an ACL injury has a negative effect on performance (34). Therefore, the effect of SMST on soccer players with ACLR, as well as its effect on the scores of FMS tests, was essential. Based on this, the present study was performed. Based on the results of the present study, coaches can use the SMST protocol to improve and correct movement restrictions and patterns identified by FMS in order to prevent re-injury. They can also identify movement restrictions and muscle imbalances using FMS and evaluate the athletes' readiness to return to play. Because returning to sports after an ACL injury is a complex and subjective process (35).

Limitations and research suggestions

Our research had limitations. Since the SMSTS training is difficult and time-consuming, many soccer players did not insist on participating in this prevention protocol. Additionally, FMS assessments were done by only one person, which can increase the chance of personal bias and influence. However, Bonazza *et al.* and Teyhen *et al.* reported that the FMS scoring system has an interrater reliability ranging between moderate to good evaluators, with an acceptable level of measurement error (25, 36). Another limitation was that impairments in rehabilitation following injury of the ACL were not known, and their impact on FMS results could not be removed. In future research, the role of FMS should be clarified as an indicator for identifying the risk of non-contact injuries in soccer players.

CONCLUSIONS

According to our results, SMST can be effective in improving FMS test item scores in soccer players with ACLR. Performing functional training appropriate to individual and test characteristics can have a positive effect on the overall score and individual items of the FMS test. The FMS test is an effective diagnostic tool for identifying previous injuries among soccer players.

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DATA AVAILABILITY

Data are available under reasonable request to the corresponding author.

CONTRIBUTIONS

ASK: design. YH: data collection. ASK: writing – original draft. HD, PS: writing – review & editing, results analysis.

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CONFLICT OF INTERESTS

The authors declare that they have no conflict of interests.

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