Research Paper: Does SportsMetrics Soccer Training Improve LESS and Dynamic Balance in Soccer Players? A randomized controlled trial

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ABSTRACT

Purpose: Compared with other sports, soccer is an activity with a relatively high incidence of injury. To decrease the number of injuries, prevent early retirement, and provide a healthy and safe environment for players, preventive programs are highly recommended. This study aimed to investigate the effect of Sportsmetrics Soccer Training (SMST) on Landing Error Scoring Systems (LESS) and dynamic balance in soccer players.

Methods: This study was a randomized controlled trial with pretest-posttest design and training (TG) and control (CG) groups. The statistical population comprised young soccer players over 18 years old recruited from Zulfaqarnasab Soccer Academy in Sanandaj City, Iran. The study participants were 29 soccer players with three years of experience in soccer clubs. The subjects were randomly assigned into TG (n=14, mean±SD age=18.40±0.5 years, mean±SD height=180.40±6.86 cm, mean±SD weight=70.47±9.62 kg) and CG (n=15, mean±SD age=18.64±0.08 years, mean±SD height=179.57±6.72 cm, mean±SD weight=64.64±6.61 kg). The TG group performed SMST three times a week for six weeks (each session lasted 35 to 45 minutes). The CG did not receive any intervention. The LESS (intraclass correlation [ICC]=0.82-0.99) and the Y-balance (ICC=0.91- 0.99) were used for assessing landing errors and dynamic balance. The obtained data were analyzed using the Analysis of Covariance (ANCOVA) (P≤0.05) in SPSS (version 24).

Results: The TG showed a significant improvement in scores of LESS (F=48.23, P=0.0001), anterior reach (F=18.26, P=0.0001), posteromedial reach (F=21.15, P=0.0001), and posterolateral reach (F=17.94, P=0.0001) in posttest compared to their baseline results.

Conclusion: The present study results showed that SMST could improve LESS score and Y-balance, so we recommend that soccer coaches use SMST to prevent injury.

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Highlights

• Specialized neuromuscular training for injury prevention should be used to improve the performance and dynamic balance of athletes in landing.

• Sports metrics soccer training (SMST) significantly affects the landing error scoring system and soccer players' balance.

• Because of the relationship between landing error, balance, and injury, it is recommended that soccer players and coaches use SMST to prevent serious injuries, including anterior cruciate ligament tear.

Plain Language Summary

Anterior cruciate ligament (ACL) injury is one of the most common soccer injuries. Athletes with this injury will be away from sports competitions for a long time. Hence injury prevention is one of the main concerns in professional soccer. However, on the one hand, most coaches, because of their specific expectations to achieve team goals, are reluctant to implement injury prevention programs. On the other hand, the effect of these programs on improving the physical performance of athletes is weak. Therefore, it is necessary to use a comprehensive and practical protocol that simultaneously prevent injury and improve physical performance sports teams. The study aimed to investigate the effect of sports metrics soccer training (SMST) on landing error scoring systems (LESS) and dynamic balance in soccer players. The results of the present study showed that SMST can improve LESS score and Y-balance. Lack of dynamic balance is one of the functional weaknesses that is very crucial in injury prevention and puts athletes at injury risk. Therefore, according to the present study results, SMST has significant effects on LESS and soccer players' balance. Because of the relationship between landing error, balance, and injury, it is recommended that soccer players and coaches use SMST to prevent serious dangerous injuries, including ACL tear.

1. Introduction

S occer is one of the most popular and attractive sports in the world. This exciting sport is dynamic, so it carries the highest risk of injury for athletes [1]. For this reason, preventing injury is one of the most important issues for clubs, coaches, and players. The results of epidemiological research showed that the prevalence of soccer injury in European leagues is 5-8 injuries per 1000 hours playing and 2-5 injuries per 1000 hours training [2]. About 72% of soccer injuries occur in the lower extremity [3]. The most worrying injury seen in sports communities, mainly soccer, is the Anterior Cruciate Ligament (ACL) tear, which causes many long-term complications for individuals and carries a heavy economic burden in the treatment and rehabilitation process for athletes and even sports clubs. About 13000 to 38000 dollars is estimated to be spent for the treatment duration of each athlete suffering ACL injury or tear [4]. Therefore identifying potential risk factors and taking preventive measures for ACL injuries are justified [5]. Abnormal biomechanics of the trunk and lower extremity are risk factors for this injury because they impose the greatest strain on the ACL [6, 7].

Specifically, the mechanisms of an ACL injury are summarized as follows: decreased knee flexion, increased hip flexion, knee valgus, decreased plantar flexion of the ankle, increased hip internal rotation, and enhanced excessive tibia rotation [8-10].

The Landing Error Scoring System (LESS) is a screening test to identify athletes with biomechanical errors in specialized sports activities that lead to injury. This test focuses more on how to land and examines the biomechanical errors that put the individual at injury risk [11, 12]. Research results showed that young soccer players get poor scores in LESS [11-13]. Namely, they lack the standard level for flexion of the knee, hip, and trunk and lower extremity performance to protect the knee joint during activities [11]. Thus, ACL injuries can be prevented by modifying the landing technique and reducing the shear force on the knee.

Knee injuries, especially noncontact ACL injuries in athletes that occur in cutting and jumping movements, may be due to insufficient muscle strength or imbalance [14, 15]. Balance is a key factor for athletes' performance. Meldrum and Finn defined balance as the ability to maintain postural stability while performing

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functional activities. This ability is responsible for the correct and regular performance of sports skills and injury prevention [16]. The relationship between balance and ACL injury is an inverse relationship. This factor is one of the most important skills in soccer that provides the ability to control dynamic body stability, i.e., returning to a static and stable state from a dynamic and unstable state during sports competitions [17]. To avoid imbalance, fall, and lower extremity injury such as ACL rupture, the center of gravity must remain within the level of support by adjusting the body's position [18]. Previous studies have shown that athletes with higher balance index scores have an increased risk of ACL injury due to poor balance and neuromuscular control [19]. Therefore, it seems necessary to pay attention to balance in athletes to prevent injury.

Injury prevention has been one of the major issues in soccer in recent years. Unfortunately, more than half of soccer coaches in the youth category do not follow or fully pursue injury prevention programs [20]. Neuromuscular training is the best and most effective way to prevent injury and enhance performance techniques. Experts in injury prevention recommend implementing these programs to coaches and athletes to avoid injuries and increase the age of exercise [21, 22]. Numerous neuromuscular training has been provided by injury prevention specialists, including FIFA11 (injury prevention program), FIFA11+, PEP (Prevent injury and Enhance Performance program), and KIPP (Knee Injury Prevention Program). Most of these programs have been provided to avoid injury. The researchers have examined the effect of these programs on performance regarding the research background and results of previous studies. In this context, Sportsmetrics Soccer Training (SMST) has been specialized in preventing injury and enhancing soccer players' performance. This protocol is a neuromuscular warm-up protocol that includes agility, reaction, speed, resistance, plyometric, coordination, and strength factors [10]. In general, the most common site of injury in soccer is the lower extremity, and the knee injury (especially ACL) is the most severe soccer injury. According to the research results, SMST successfully prevents lower extremity (especially ACL) injury. But previous research has not investigated the effect of SMST on balance and landing performance. Regarding the importance of SMST in preventing injury, avoiding knee injuries (especially ACL), and enhancing athletes' performance level, this study aimed to investigate the effect of SMST on LESS and dynamic balance of healthy soccer players.

2. Materials and Methods

Research design

This study is a randomized clinical trial with a pretest-posttest design and Training Group (TG) and Control Group (CG). The study was done at the university research laboratory. All subjects were randomly assigned into the TG or CG group using the random number generator software (V1.4). This study was approved by the Research Ethics Committee of Bu-Ali Sina University (IR.BASU.REC.1398.018) and registered at the Iranian Registry of Clinical Trials (IRCT20200307046716N1).

Sampling

The participants in this study were young soccer players over 18 years old from Zulfaqarnasab Soccer Academy in Sanandaj City, Iran. The total sample size was calculated 26 (13 subjects in each group) using "G-Power" software (subject power: 0.82, effect size: 0.97, and significance level: 0.05) [23].

For the possible drop in the subjects during the study, 15 subjects were considered for each group. Finally, one subject from the TG was excluded for excessive absence in the exercises. The inclusion criteria were soccer players between 18 to 25 years old, having three years of soccer experience on the club level, a regular presence at training sessions, and athletes' consent to participate in the training program. The exclusion criteria were the absence of more than two sessions in training, a history of any injury and surgery in the lower extremity during the last year, a history of ACL injury in the previous year, and participation in bodybuilding programs during the training program.

Data collection

Landing Error Scoring System (LESS)

The Landing Error Scoring System (LESS) (Intra-class Correlation Coefficient [ICC]=0.82-0.99) [24] is a screening tool used to assess jump-landing errors. This test starts with a forward jump from the 30-cm high box on the target line, which is placed at half of the participant's height. First, the participants were instructed to land on the target line and, after that, jump for maximal height immediately. This task is repeated three times, and the average values of the three jump-landing were recorded. No instruction was given to participants during performing the jump-landing task. Two digital video cameras (model EXILIM EX-ZR1000; Casio, Corpora-
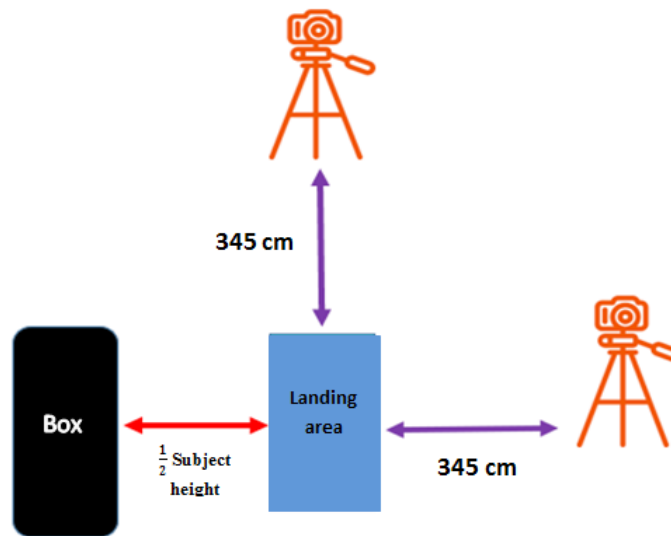
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Figure 1. Camera locations and box distance from cameras and landing place

tion of Japan) were placed 345 cm in front of and to the side of the participant to record frontal and sagittal images (Figure 1). By examining the recorded videos, both lower limbs were analyzed according to the 17 items, and the final scores of the subjects were recorded. The norm of scores was assessed as the total score: below four, excellent; four to six, acceptable; above six, poor [13] (Figure 2).

Y-balance

The Y-balance test (ICC=0.91-0.99) [25] (Y-balance machine, Ghamat Pouyan Company, Iran) was used to assess dynamic balance. To perform this test, the subject places his bare foot on the center point of the device. With hands on the waist and without lifting the heel off the ground, the subject moves the suspended leg forward by bending the knee of the fixed leg. The last point touched by foot was intended as a record of the anterior direction. Then the subject does the same task by returning to the first state without putting his foot on the ground, maintaining body balance, and it was done to the right and left (posteromedial and posterolateral). It is important to understand when the suspended foot moves in the direction where the fixed foot is, and the foot must pass behind it to continue the path (Figure 3). The length of a person's foot was measured with a tape measure from the distance from the The anterior superior iliac spine (ASIS) to the internal malleolus. To calculate the total balance for each foot, first, the records of three directions are added, then divided by the length of the foot, and afterward, it is multiplied by three. Finally, the result of this expression is multiplied by 100 [26].
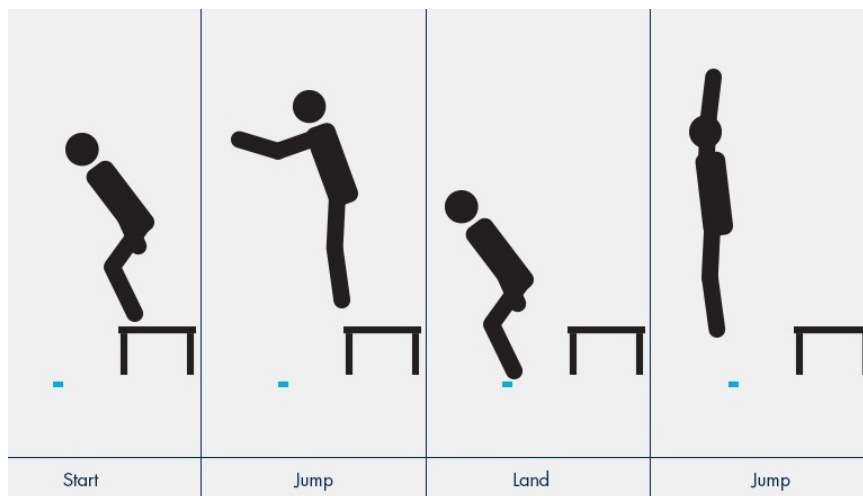

Figure 2. Performance and evaluating the landing error scoring system

Table 1. Sportsmetrics soccer training program [23]

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 *3
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 back-back, 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 repetitions	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 * 4

Note: yd: yard.

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Sportsmetrics exercises

The SMST protocol has several basic parts of the performance factors required by soccer players. It includes four pieces of training that include agility and reaction, speed and endurance, plyometric, and strength. This protocol is programmed such that soccer players do new exercises in each section every week, but the nature of any of the training sections does not change. It is designed based on the factor of the relevant section of the training [23]. The tools needed to perform the exercises include cones and training funnel, resistance theraBand, ladder, and Pilates band. The training program was variable for each week, and the TG at the beginning of each week was taught the whole weekly program. TG (n=15) participated in the program three times a week for six weeks. The training program takes 35 to 45 minutes per session. The control group did not receive any intervention (Table 1).

Data analysis

According to the assumptions of the Analysis of Covariance (ANCOVA) test, the normality of data distribution was checked by the Shapiro-Wilk test. Also, the equality of intergroup variances was checked by Levene's test, and the homogeneity of regression line slopes by regression betas. By observing the assumptions, this test was used to examine between-group differences. Results were analyzed in SPSS 24 software at the significance level of 95% ($P<0.05$).

3. Results

At the baseline, there were non-significant differences between the groups regarding the demographic characteristics ($P≥0.05$). The demographic characteristics of participants are presented in Table 2. The measurement

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Table 2. Demographic characteristic of the participants

Variable	Mean±SD		t	P
	Training Group (TG)	Control Group (CG)		
Age (y)	18.40±0.5	18.64±0.08	-0.783	0.213
Height (cm)	180.40±6.86	179.57±6.72	0.328	0.501
Weight (kg)	70.47±9.62	64.64±6.61	1.885	0.153
BMI (kg/m²)	21.59±2.14	20.40±1.42	1.744	0.093
Sport experience (y)	3.93±0.80	4.36±0.92	-1.320	0.201

records of reach distance and LESS score were normally distributed in groups.

The results showed that TG demonstrated a lower LESS score and higher reach distance than the CG at the posttest. Within-group comparisons are presented in Table 3. The ANCOVA results showed a significant difference between the two research groups in all variables in the posttest after controlling the effect of the pretest (covariate) (P<0.05).

4. Discussion

Results of the present study indicate that sportsmetrics soccer training protocol affects the landing error scoring system and the dynamic balance of young soccer players. According to the study, after six weeks of SMST, the LESS score in the TG participants decreased by 53%, and the reach distance of the dominant leg increased by 17%. These results indicate an improvement in the balance and kinematics of the landing participants of the TG group and reduce the risk of injury. Due to the different consequences of injury for athletes, various articles have explored injury prevention protocols [27]. Neuro-

muscular training has been reported to reduce the risks of lower limb injuries significantly [28]. These exercises increase the activity of the gamma efferent nerves in the muscles by stimulating the muscle spindles. The increasing sensitivity in the spindles improves the sense of joint perception, which significantly affects joint control [29]. This effect can prevent ACL injury by improving balance. SMST focuses on decreasing landing forces and improving lower limb alignment from a valgus position to a neutral position by teaching lower limb neuromuscular control. In this protocol, these concepts are first implemented with strength training (lower extremity, upper extremity, and core) and flexibility [30].

Numerous studies have investigated the effect of plyometric training on landing performance. The results indicate that individuals who perform plyometric training have better motor control [31, 32]. One factor affecting the safety and effectiveness of knee stability is having dynamic stability to reduce excessive forces on the knee, which leads to reduced injury risk [33]. Having optimal muscle strength in the core area and lower extremities is important in protecting the knee joint. In addition to sufficient strength in the core area, dynamic stability of
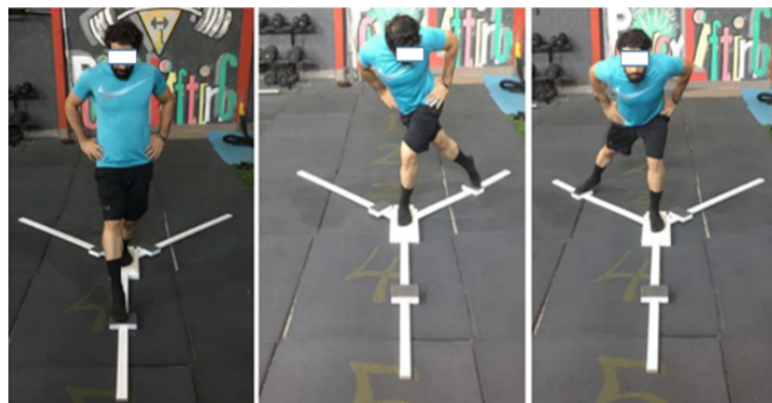

Figure 3. Y-balance test

Table 3. Effect of sportsmetrics soccer training on Landing Error Scoring System (LESS) and reach distant

Variable	Groups	Mean±SD		Change Relative to Baselines § (%)	Between-Group Results		
		Baseline	After Training		F	P	ES
LESS (score)	TG	11.73±1.98	5.46±2.35	53.45 ↓	48.23	0.0001*	0.650
	CG	10.71±1.89	9.00±1.80	15.96 ↓			
Reach distant (cm)	TG	85.51±5.12	100.28±6.15	17.27 ↑	34.33	0.0001*	0.569
	CG	85.80±4.89	88.54±6.48	3.19 ↑			
Anterior reach (cm)	TG	79.53±6.34	89.40±5.61	12.41 ↑	18.26	0.0001*	0.413
	CG	79.21±3.23	79.93±6.08	0.90 ↑			
Posteromedial reach (cm)	TG	74.00±8.77	91.07±8.21	23.06 ↑	21.15	0.0001*	0.449
	CG	75.29±6.96	79.71±8.07	5.87 ↑			
Posterolateral reach (cm)	TG	87.00±6.31	100.87±7.89	15.94 ↑	17.94	0.0001*	0.408
	CG	87.00±6.70	89.36±7.05	2.71 ↑			

Abbreviations: TG, Training Group; CG, Control Ggroup; ES, partial Eta-Squared;
§ Percent change (↓decrease, ↑ increase); *Significant.

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the joint and dynamic motor control is important in improving LESS test scores [34]. Based on what was discussed and the results of balance and LESS tests in our research, performing SMST affects the dynamic stability of the joint and motor control of soccer players. So, a significant improvement was observed in the training group. These results are consistent with the studies of Noyes et al. [23], Rey et al. [35], Klugman et al. [36], Lagas et al. [37], and O'Malley et al. [38], who investigated neuromuscular injury prevention protocols on knee performance.

Training volume is a critical factor in improving neuromuscular control during dynamic activities such as jumping, landing, and dynamic balance [31]. Current Warm-up programs are usually performed for a brief warm-up of 10 to 15 minutes and sometimes 20 minutes [31]. Having a suitable time to prepare the whole body motor system and the main muscles active in the match is one of the features of SMST. This program is performed for 35 to 45 minutes per training session. Therefore, the training and movements in the program had a very good number of repetitions and distances. In general, high repetitions of training in SMST improved the dynamic motor performance of the TG.

The important muscles in knee performance for extension and flexion movements are the quadriceps and hamstrings. Muscle imbalance between these two muscles leads to a risk of knee joint injury. This complication is associated with a neuromuscular defect of quadriceps dominance. If the ability to activate quadriceps muscles is greater than normal and faster than the hamstring muscles, knee performance during landing is associated with knee extension, which is one of the factors in ACL tear during landing [8]. Thus, the strategies of activating quadriceps and knee flexion by hamstrings muscles are very important and effective in scoring LESS during landing. The results regarding the fact that SMST performs strength training indicated a good functional muscular balance between the quadriceps and hamstrings during the training performed by the TG because the LESS scores improved significantly after the test.

Simultaneous landing of the legs is another item evaluated and scored during the landing-jump error analysis and examination. It has a special relationship with the neuromuscular performance defect of foot dominance. Consequently, asymmetry of foot contact during landing is a risk factor for ACL injury. Experts reported that muscle imbalance on both sides of the extremities (right and left) causes this defect [8]. The effect of plyometric short jump training and strength training on empowering the muscles on both sides of the lower extremities and motor control can be seen in SMST that solves the problem of the neuromuscular defect in leg dominance.

According to our results, SMST has had a significant effect on the dynamic balance of the TG. The present study is consistent with the study of Impellizzeri et al.

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[39], Heleno et al. [40], and Steffen et al. [41] on the balance of soccer players. Joint stability and balance are provided by two static and dynamic mechanisms. Static stability is provided by joint capsules, ligaments, and bones. Dynamic stability is provided by muscle performance. The lateral ligaments in the knee joint protect the knee secondarily and reflexively. Warm-up increases the sensitivity of mechanical receptors in the joints by enhancing blood flow in all active muscle tissue and raising the oxygen level of muscle. This mechanism stimulates the tissues supporting and protecting joints to maintain and control the body in dynamic movements [42]. This process returns the body to stability and restores the athlete's balance in unstable positions. There is a direct relationship between balance and muscle strength. The results of studies have shown that strength factor and plyometric training improve athletes' balance [43, 44]. Therefore, strength training was performed by pilates band on the muscles of the lower extremity (gluteal, adductors, hamstrings, quadriceps, and calf muscles) and the muscles of the core area in the present training. Considering the SMST, this program is a combination of functional factors in a training session. In this regard, significant effects were observed in a study conducted in 2019 on the athletes' balance during a training period of balance and plyometric training in a coordinated and regular manner. This result is consistent with the present study results [43]. The faster activity of core muscles before a movement pattern by the lower extremities significantly affects the athletes' balance during movement. It is necessary to dedicate part of warm-up training to prepare these muscles during activity [45]. According to numerous studies, performing core stability training and strengthening this area significantly affects dynamic balance and neuromuscular control in soccer players [45]. Accordingly, the present research results reported the significant impact of SMST on balance regarding the training for strengthening central body stability. The SMST includes a dynamic warm-up, plyometric jump training, strengthening (lower extremity, upper extremity, and core), and flexibility, with special emphasis on balance. Decreasing landing forces and improving lower limb alignment from a valgus position to a neutral position can improve the balance, as well as the kinematics of the knee and lower extremity during landing and reduce the ACL injuries.

5. Conclusion

Because most ACL injuries are noncontact and caused by unsafe landing, it is necessary to attend to the way athletes land. Specialized neuromuscular training for in-jury prevention should be performed to improve the performance of athletes landing. Lack of dynamic balance is one of the functional weaknesses and puts athletes at injury risk. According to the present study, SMST significantly affects the landing error scoring system and soccer players' balance. Due to the relationship between landing error, and balance and injury, it is recommended that soccer players and coaches use SMST to prevent serious injuries, including ACL tear.

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