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Title: The Effect of a Six-Week FUNBALL Warm-Up Program on Lower Limb Injury Risk Factors and Functional Performance in Male Soccer Players Aged 17–20 Years

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Abstract

Purpose: The dynamic, multidirectional, high-intensity, and competitive demands of soccer place young players at considerable risk of lower-limb injury. This study aimed to investigate the effect of a six-week FUNBALL warm-up program on injury risk screening tests (including the Landing Error Scoring System (LESS) and Tuck Jump) and functional tests (including the Functional Movement Screen (FMS) and NINE Test) in male soccer players aged 17–20 years.

Methods: In this quasi-experimental study, thirty male soccer players aged 17–20 years with no lower-limb musculoskeletal injury in the preceding six months were assigned in a 1:1 ratio to an intervention group (FUNBALL; n = 15) or a control group (n = 15). Over six weeks, the intervention group completed the FUNBALL warm-up three times weekly for about 20 minutes per session, combining balance, core-stability, eccentric hamstring, gluteal-activation, plyometric, and running/sprinting exercises with ball-based cognitive challenges, while the control group continued its usual routine warm-up. Tuck Jump, LESS, FMS, and the Nine-Test were assessed before and after the intervention. Normality was evaluated with the Shapiro–Wilk test; ANCOVA, adjusted for baseline scores, was used for normally distributed variables, and the Mann–Whitney U test for the non-normally distributed Tuck Jump variable, with significance set at $p \leq 0.05$.

Results: Baseline characteristics did not differ between groups ($p > 0.05$), and both groups improved significantly within group. ANCOVA showed significantly greater post-test gains in the FUNBALL group for LESS ($F(1,28)=188.88$, $p=0.001$, $\eta^2=0.87$), FMS ($F(1,28)=304.49$, $p=0.001$, $\eta^2=0.91$), and NINE Test ($F(1,28)=21.59$, $p=0.001$, $\eta^2=0.44$) at post-test in favor of the FUNBALL group.). No significant between-group difference was found for the Tuck Jump at post-test ($p = 0.30$).

Conclusion: A six-week FUNBALL warm-up produced greater gains in landing quality, functional stability, and overall performance than a routine warm-up in male soccer players aged 17–20 years, though it offered no added benefit for Tuck Jump performance. FUNBALL may serve as a practical alternative to conventional warm-ups for lowering injury-risk indicators in young male players; findings should not be generalized to females, and future research should assess injury incidence over longer follow-up.

Keywords: FUNBALL, LESS, Tuck Jump, FMS, Nine Test, Lower Extremity Injury

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Plain Language Summary

This study investigated whether a 6-week FUNBALL warm-up program could help young male soccer players aged 17–20 years reduce injury risk factors and improve movement. Thirty players were divided into two groups: FUNBALL and regular warm-up. Jumping ability improved in both groups after six weeks, with no meaningful difference between them. Notably, the FUNBALL group showed greater improvement in landing, body control, and overall movement quality, which meant a lower risk of injury, especially knee injuries such as ACL tears. In general, FUNBALL was more effective than a normal warm-up for improving safe movement and reducing injury risk, even though it did not improve all tests more than the regular warm-up.

Highlights

- The 6-week FUNBALL program improved functional movement, landing quality, and stability in young soccer players.
- Both groups showed improvement in jumping ability, with no significant difference between them.
- FUNBALL led to greater reductions in movement errors and injury risk indicators than routine warm-up.
- Overall, FUNBALL was more effective in improving injury-related movement patterns.

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Introduction

As the most widely played sport in the world, soccer demands frequent bursts of acceleration and deceleration, sharp changes of direction, and repeated jumping and landing — actions that, combined with frequent physical contact, place players at greater injury risk than athletes in many individual sports. Young players are especially vulnerable during periods of rapid growth and puberty (1). Among young Brazilian players, one study reported 1.86 injuries per 1000 hours of exposure overall, rising to 22.48 injuries per 1000 competition hours in the under-20 age group (2). A separate investigation of amateur players aged 17–19 years documented 12.9 injuries per 1000 hours of match exposure (3). In a sample of 30 soccer players, roughly one in five displayed knee valgus and other faulty landing mechanics at initial ground contact — patterns linked to elevated ACL-injury risk (4).

Despite this evidence, gaps remain in how injury-prevention strategies are implemented in practice (1). FUNBALL, a multimodal prevention program designed for male players aged 13–19, has shown promise in reducing soccer-related injuries in prior work. Its content spans balance, core stability, hamstring strength, gluteal activation, plyometrics, and running/sprint drills, with two distinct exercises offered within each category to sustain variety and engagement. The program is designed to replace a team's standard warm-up within regular training sessions (5).

Evaluating how well such programs work requires reliable screening tools that quantify injury risk factors, which in turn helps coaches and sport scientists design training that both protects players and enhances performance. Engaging programs such as FUNBALL may also boost motivation and participation — factors that matter for sustained adherence to long-term training (6). Tests built around repeated jumping, which force athletes to react to destabilizing forces, are one such tool. The Tuck Jump Assessment (TJA) is a practical field-based method for detecting plyometric technique flaws associated with anterior cruciate ligament (ACL) injury risk, though quantitative data on frontal-plane projection angles in young athletes obtained through practical assessment methods remain limited (7).

The LESS was designed to capture landing and jumping biomechanics that relate to a heightened likelihood of ACL injury, with particular emphasis on identifying faulty movement patterns. It evaluates elements such as knee alignment and overall stability during landing (8), scoring athletes on their technique and flagging errors like knee valgus as markers of elevated injury risk. Among

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elite youth players, athletes scoring 5 or higher on the LESS were considerably more likely to sustain an ACL injury than those scoring below 5; the tool demonstrated 86% sensitivity and 64% specificity for predicting injury (4).

Both the Nine-Test battery and FMS serve as useful screening instruments for detecting functional movement deficits in soccer players and support injury-prevention planning. According to a systematic review of exercise interventions targeting FMS and Nine-Test outcomes, score improvements following targeted training were reported in the majority of studies (9). As one of the most widely adopted screening tools in sports science, FMS consists of seven movement tasks aimed at revealing muscular weakness, asymmetry, and dysfunctional movement. Evidence links FMS performance to injury risk among soccer players: Duncan et al., for example, reported that lower FMS scores in 105 adolescent players aged 13–16 years were significantly related to movement patterns associated with greater ACL-injury risk (10).

The Nine-Test Screening Battery similarly targets limitations in fundamental movement patterns that predict injury risk, using nine tasks to evaluate movement quality and detect functional asymmetries. A reliability study of the tool in Swedish male soccer players aged 17–28 years supported its intra-rater consistency (11).

Given these considerations, the present study set out to determine whether the FUNBALL program produces different effects on injury-related risk factors and functional performance outcomes compared with a routine warm-up in male soccer players aged 17–20 years.

Materials and Methods

The present quasi-experimental study involved 30 male soccer players who were selected using convenience sampling and randomly divided into two groups: FUNBALL training (N=15) and control(N=15). The sample size was determined using G-Power software ($\alpha = 0.05$, power = 0.80) based on an effect size of 0.50 reported in a previous similar study, resulting in a total sample of 30 participants (12).

Players were assigned to the FUNBALL and control groups in a 1:1 ratio using a simple randomization procedure. The assessor who collected the pre- and post-intervention outcome measures remained blinded to group allocation throughout testing. However, given the nature of

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the exercise intervention, it was not possible to blind the participants themselves or the coach responsible for delivering the FUNBALL program.

Athletes were eligible for inclusion if they were 17–20 years old with active football experience, no lower-limb musculoskeletal injury in the preceding six months, no recent history of lower-limb surgery, and no concurrent involvement in other musculoskeletal-related research. Players were excluded from the analysis in cases of irregular attendance, voluntary withdrawal, or two consecutive missed training sessions (13,14).

Before the start of the research, all participants were informed about the steps and process of the study and signed a written consent form. In addition, the participants were given explanations about the procedure, and then they executed the Tuck Jump, LESS, FMS, and NINE tests. The intervention group then carried out its assigned program three times a week for six weeks, approximately 20 minutes per session, under the supervision of the team coach together with a corrective-exercise specialist. After the intervention, all variables were re-evaluated in both groups, as in the pre-test conditions.

Tuck Jump Test

To perform, the athlete starts from a shoulder-width stance and jumps vertically while driving the knees upward to their maximum height. At the top of the movement, the thighs are expected to be parallel to the floor. After each landing, the participant proceeds directly into the following tuck jump for a total duration of 10 seconds. (7). Two video cameras, positioned according to the participant's height and aligned with the frontal and sagittal planes, recorded each trial for later analysis using Kinovea software. Athletes were classified as showing trunk-control deficits if they failed to land in the same spot as their takeoff, did not achieve parallel thigh alignment at peak height, or paused between successive jumps during the 10-second test (15).

Landing Error Scoring System (LESS)

For the LESS, participants jumped forward from a 30-cm platform, landing at a distance roughly equal to half their height before immediately performing a maximal vertical jump. During

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familiarization, participants were told to jump as high as possible on landing, but received no corrective feedback unless a trial was performed incorrectly; two practice attempts preceded three scored trials. A trial was repeated once if the participant failed to land at the required distance or did not perform a maximal vertical jump (16).

Two tripod-mounted video cameras were placed at distances of 4.8 and 4 meters to record images of the subjects jumping from the frontal and sagittal views, respectively. The LESS test has 17 items. One set of these questions is related to the position of the lower limbs and trunk at initial contact (items 1–6). The other set assesses errors in foot position (items 7–11), which are assessed at the initial contact (item 11), the moment when the entire sole of the foot is in contact with the ground (items 7 and 8), and between the time of initial contact and maximum knee flexion angle (items 9 and 10). The third set evaluates lower-limb and trunk kinematics from initial ground contact to either maximum knee flexion (items 12–14) or maximum knee valgus (item 15). The final score for each landing is calculated from the sum of the scores for all items (0–15), with higher scores (more errors) indicating more dangerous landing techniques. Items 16 and 17 are general and subjective and are not included in the total score. Finally, the average of the three jumps was recorded as the final score for each individual (17).

Functional Movement Screen (FMS)

Each of the FMS's seven tasks — deep squat, hurdle step, in-line lunge, shoulder mobility, active straight-leg raise, trunk-stability push-up, and rotary stability — is scored from 0 to 3: 3 for a technically correct movement, 2 if compensations are present, 1 if the movement cannot be completed, and 0 if pain occurs during the test. Summing the seven task scores yields a composite ranging from 0 (pain throughout) to 21 (flawless performance across all movements) (18,19).

Nine-Test Screening Battery

The Nine-Test battery evaluates deep squat, single-leg squat, in-line lunge, active hip flexion, straight-leg raise, push-up, diagonal lift, seated rotation, and functional shoulder mobility, capturing the quality of functional movement across a range of tasks. Each item is rated 0–3: a top

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score of 3 reflects movement free of asymmetry or compensation; 2 indicates minor compensatory movements (6); 1 indicates the task could not be completed without major compensation; and 0 is assigned whenever pain is present, regardless of technique. The maximum achievable composite score is therefore 27 points (20).

Intervention:

FUNBALL Program

FUNBALL is built around six mandatory exercise categories — balance, core stability, eccentric hamstring work, gluteal activation, plyometrics, and running/sprinting — each offering two exercise variants to sustain variety (21), plus an optional set of three games intended to make the program more engaging. Exercises progress through five or six levels of increasing physical and cognitive demand and must be completed sequentially, advancing to the next level only once proper technique is demonstrated under instructor supervision. A full session takes roughly 15–20 minutes (Table 1) (21,22).

Table (1). FUNBALL Warm-up Program

Exercises		Reps/Duration	Levels
Balance	Single-leg stance	2×30 sec (each leg)	6
	Y-Balance	3×6-8 reps (each leg)	6
Core Stability	Plank and Side plank	2×20-40 sec (each position)	6
	Straight-arm plank	2×8-12 reps	6
Hamstring Eccentrics	Nordic hamstring	1-2× 3-10 reps	5
	Hamstring walk-out	2-3 ×30 sec	5
Glute Activation	Head, Shoulder, Hip, Knee, …	2 ×6-10 reps	6
	Squat Lunges	2-3 ×8-12 reps	6
Plyometric	Forward jumps	4 ×3 jumps	5
	Skater jumps	4 reps (2 each leg)	5

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Running/Sprinting	Diagonal	3 reps	6
	Forward-Backward	3 reps	6
Games	Tic-Tac-Toe	3-5 games	_
	Header game	3-5 reps (each player)	_
	Dribbling game	3-5 games	_

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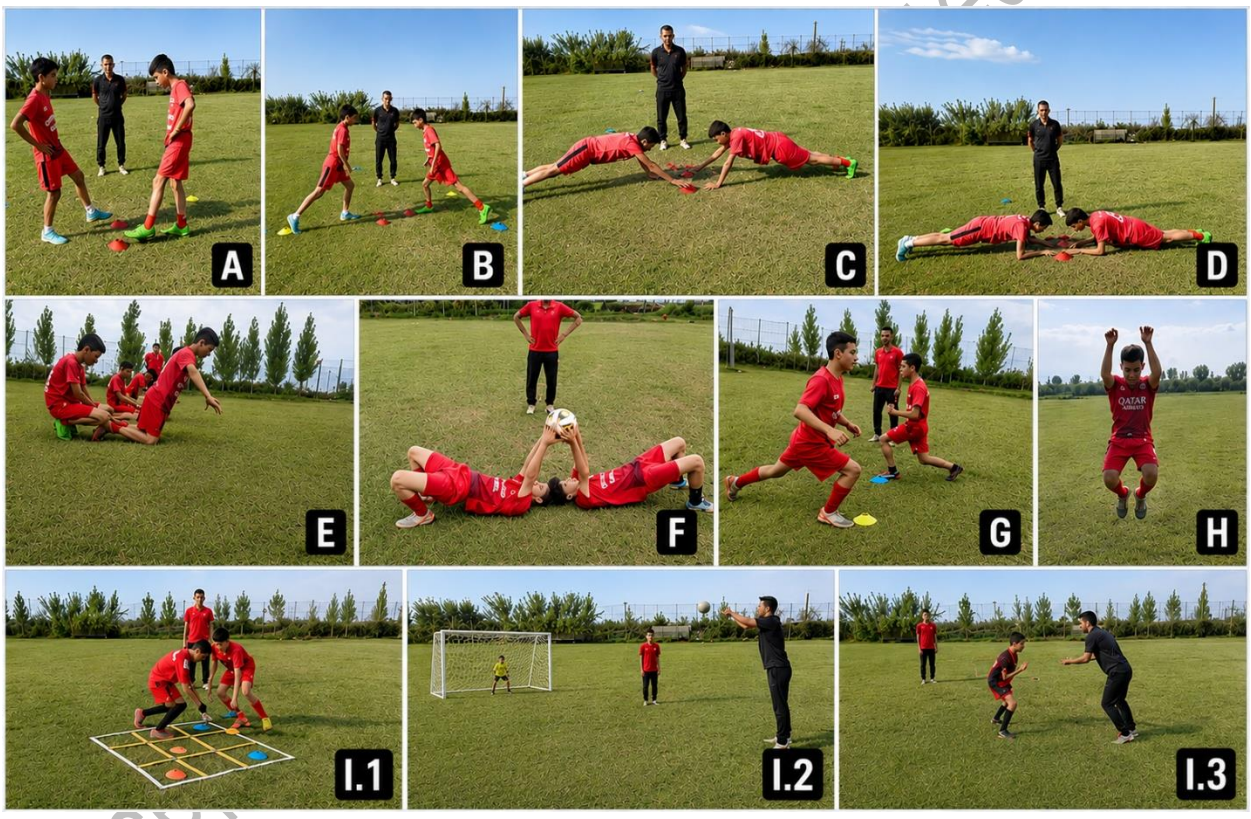


Figure 1. Examples of the FUNBALL training program: A. Single Leg Stance, B. Y-Balance, C. Straight Arm Plank, D. Plank, E. Nordic Hamstring, F. Hamstring Walk-out, G. Squat lunge, H. Forward Jumps, I. Games: 1. Tic-Tac-Toe, 2. Header game, 3. Dribbling game

Control group

The control group followed a routine soccer warm-up for approximately 20 minutes, consisting of low-intensity jogging, dynamic mobility exercises (e.g., high knees, butt kicks, walking lunges,

and leg swings), basic jumping activities (e.g., squat jumps, vertical jumps, and jumping jacks), and soccer-specific drills (e.g., passing and short accelerations). The warm-up was performed at a moderate intensity.

Data analysis

Descriptive statistics (means and standard deviations) characterized the two groups, supplemented by graphical comparisons. In the inferential phase, normality was evaluated using the Shapiro–Wilk test, followed by ANCOVA and the Mann–Whitney U test for comparisons between groups, and a paired t-test and Wilcoxon test for within-group comparisons. Statistical significance was set at $p \leq 0.05$, and all analyses were performed in SPSS version 26.

Results

In the descriptive statistics section, data were collected and analyzed to provide a comprehensive description of the characteristics of the groups. The findings from these measurements are summarized in Table 2. At baseline, no significant differences were observed between the groups ($p > 0.05$). Baseline characteristics of the two groups were compared using independent-samples t-tests.

Table (2). Baseline characteristics of participants (Mean ± SD)

Variable	Control (n=15)	FUNBALL (n=15)	p-value
Age (years)	18.86 ± 1.12	19.13 ± 0.83	0.46
Height (m)	1.75 ± 0.30	1.77 ± 0.04	0.22
Weight (kg)	69.66 ± 4.00	70.96 ± 2.60	0.20
BMI (kg/m²)	23.01 ± 1.36	22.88 ± 1.54	0.46
Sport experience (years)	4.13 ± 1.00	4.26 ± 0.96	0.71

Shapiro–Wilk testing indicated a non-normal distribution for Tuck Jump scores, whereas LESS, FMS, and Nine-Test scores were normally distributed. Because Tuck Jump data were non-normal, the post-test between-group comparison used the Mann–Whitney U test and showed no significant

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difference ($p = 0.30$), even though within-group Wilcoxon tests showed significant improvement in both groups ($p < 0.001$).

Between-group comparisons were performed using ANCOVA, controlling for baseline values. A significant effect of the FUNBALL warm-up program was observed for all three variables ($p = 0.001$), with the FUNBALL group demonstrating greater improvements than the routine group. Effect sizes (partial eta squared) were large ($\eta^2 = 0.87–0.91$), indicating a substantial intervention effect (Table 3) (23).

Table (3). Comparison of pre-test and post-test scores between Routine and FUNBALL with within-group and between-group (ANCOVA) results

Variable	Group	Pre-test (Mean ± SD)	Post-test (Mean ± SD)	Δ Change	Within-group p	Between-group (F, df)	p-value	Effect Size (η^2)
Tuck Jump	Routine	3.00 ± 1.06	1.73 ± 0.79	-1.27	0.001†	—	0.30‡	—
	FUNBALL	3.13 ± 1.35	1.46 ± 0.74	-1.67	0.001†			
LESS	Routine	5.66 ± 1.04	4.86 ± 1.06	-0.80	0.001	F (1,28) =188.88	0.001	0.87
	FUNBALL	5.60 ± 0.98	2.46 ± 0.99	-3.14	0.001			
FMS	Routine	12.20 ± 1.74	14.06 ± 1.57	+1.86	0.001	F (1,28) =304.49	0.001	0.91
	FUNBALL	12.06 ± 1.57	17.20 ± 1.65	+5.14	0.001			
NINE Test	Routine	16.33 ± 2.19	17.53 ± 2.26	+1.20	0.001	F (1,28) =21.59	0.001	0.91
	FUNBALL	15.93 ± 1.83	19.80 ± 2.80	+3.87	0.001			

† Wilcoxon signed-rank test was used for within-group comparisons of the Tuck Jump.

‡ Mann–Whitney U test was used for between-group comparison in the Tuck Jump.

The results showed that a six-week FUNBALL program significantly improved the performance of LESS, FMS, and NINE tests; however, there was no significant difference between groups in the Tuck Jump Assessment.

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Discussion

This study aimed to investigate the effect of a six-week FUNBALL warm-up program on lower extremity injury risk screening tests and performance indicators in male soccer players aged 17–20 years. Assessments were performed using tools such as the Tuck Jump Test (for plyometric performance and assessing risk factors of ACL injury), the LESS to evaluate landing biomechanics, the Functional Movement Screening Test (FMS) for motor stability, and the Nine Test for overall motor performance.

In the Tuck Jump test, both the FUNBALL and routine groups showed significant within-group improvements, indicating a reduction in jump time and, therefore, increased plyometric efficiency and reduced risk of ACL injury. However, no significant between-group differences were observed. This finding suggests that the routine warm-up may have provided a sufficient neuromuscular and plyometric stimulus to improve Tuck Jump performance. The inclusion of dynamic movements and jumping exercises in the routine warm-up may have contributed to these improvements. In contrast, the broader components of the FUNBALL program, including balance, core stability, strength, and cognitive-motor exercises, may explain its greater effects on other injury risk screening measures. The properties of dynamic warm-up, such as increased muscle temperature, neuromuscular activation, and improved myosin phosphorylation, appear to increase the elasticity of muscles and tendons, which in turn leads to reduced muscle viscosity and improved energy metabolism (3). This pattern echoes other soccer-based warm-up research: Gok et al. (2023) found FIFA 11+ meaningfully improved vertical-jump performance in young players (24), consistent with the within-group gains seen here; Zois et al. (2015) reported that high-intensity warm-up raised vertical-jump height more than a traditional warm-up (25); and Yanci et al. (2019) found jump performance improved with warm-up but dropped again once warm-ups ran too long (26). Some findings diverge, however — Abade et al. (2017) found jump gains with varied re-warm-up activities in some but not all conditions (27), and Szymanski et al. (2011) reported that static-stretch warm-up reduced jump performance more than dynamic warm-up did (28).

The FUNBALL group's clear drop in LESS scores after the intervention can be understood through both biomechanical and neurophysiological pathways. FUNBALL's plyometric and balance work likely improves how forces are distributed across the knee by strengthening coordination between agonist and antagonist muscles (e.g., quadriceps and hamstrings), which limits dynamic valgus (3). This lines up with prior research on how structured warm-up shapes biomechanical patterns:

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Pankaj and Gill (2021) found that FIFA 11+ significantly cut landing errors among young players (29); Islami et al. (2023) reported that FIFA 11+, via its neuromuscular-control focus, lowered LESS scores and estimated ACL-injury risk (30); and a systematic review by Hanzlikova and Hébert-Losier (2020) confirmed LESS as reliable and valid, noting 20–30% score reductions with programs like FIFA 11+ (31). Not every study agrees — Padua et al. (2015) found LESS predictive of ACL-injury risk in young athletes but noted that short-duration warm-up programs did not always yield significant between-group differences (8), and Sharma and Thakkar (2020) reported that although LESS is highly sensitive to injury risk generally, score reductions were smaller with traditional warm-ups than with programs such as FIFA 11+ (4).

The present findings also show a significant FUNBALL-group advantage in FMS scores ($p = 0.000$, $\eta^2 = 0.91$) and Nine-Test scores ($p = 0.000$, $\eta^2 = 0.44$), indicating improved stability, better functional movement quality, and fewer motor deficits, relative to the more modest gains observed in the routine group. These results are consistent with other work on neuromuscular training and functional screening. FUNBALL's core-stability and plyometric components likely enhance movement synergy between the trunk and lower-limb musculature (32); for example, Bakken et al. (2017) found that Nine-Test scores improved across a competitive season with regular training in professional players (9), Flodström et al. (2016) reported reduced motor deficits following functional training in amateur athletes using the same test (20), and Sañudo et al. (2019) found that integrated neuromuscular training raised FMS scores by 15–25% in young athletes (33). Some studies diverge, though — Rosas et al. (2016) found that weighted jump training improved Nine-Test scores but noted no significant additional benefit from short-term warm-up programs specifically (34), and Ajanaw (2019) found that plyometric training improved general physical fitness but produced smaller-than-expected gains on Nine-Test screening scores (35).

The optional game-based activities in FUNBALL likely add variety and further support movement quality (36), a pattern Ding et al. (2022) also observed in warm-up programs designed for children and adolescents, which raised screening scores in young athletes (37). Practicing at least twice a week probably also helps sustain adherence and outcomes. The more modest gains in the routine group may partly stem from its lower cognitive variety; among young Iranian players facing limited training resources, more engaging programs such as FUNBALL appear to elicit stronger responses, in line with Selmi et al.'s (2024) findings on the emotional benefits of varied warm-up

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(38). Sikora and Heesch (2022) similarly found that FIFA 11+ improved Y-Balance performance, though they suggested functional screens such as FMS could benefit from tighter integration into warm-up design (39).

Conclusion:

A six-week FUNBALL warm-up program improved landing quality, movement stability, and overall functional performance in male soccer players aged 17–20 years, without producing a significant effect on Tuck Jump performance. By combining balance exercises, plyometrics, and cognitive challenges, the program reduced lower-extremity injury-risk factors more effectively than a routine warm-up, making it a viable option for coaches seeking to lower injury risk in young male athletes. These findings should not be generalized to female athletes. Future studies should examine actual injury incidence using longer follow-up periods and evaluate the effects of the FUNBALL warm-up program in female players and other age categories.

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Research Ethics Statement

Compliance with ethical principles was maintained throughout the study. All research procedures were conducted in accordance with the ethical guidelines of the Physical Education and Sports Science Research Institute (ethics approval code: IR.SSRC.REC.1404.088). Before the commencement of the study and measurements, all participants were informed about the research procedures and provided written informed consent by completing a consent form.

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Authors' Contribution

Zahra Saharkhiz Tochahi: contributed to the conceptualization and design of the study, methodology, data collection, data analysis, interpretation of the results, and drafting and revision of the manuscript.

Raheleh Ghaffari Cherati: contributed to the study design, interpretation of the results, supervision, and critical revision of the manuscript.

Seyed Hossein Mirkarimpour: contributed to the conceptualization and design of the study, supervision, interpretation of the results, and critical revision of the manuscript.

Qasemali Karimaei: contributed to the conceptualization of the study, interpretation of the results, and critical revision of the manuscript.

All authors reviewed and approved the final version of the manuscript before submission.

Conflict of Interest

The authors declare no conflicts of interest.

AI Use Statement

Artificial intelligence (AI) tools were used only for language editing, grammar correction, and improvement of academic writing during the preparation of this manuscript. All study design, data collection, statistical analyses, interpretation of results, and scientific conclusions were performed solely by the authors, who take full responsibility for the content of the manuscript.

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