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ORIGINAL ARTICLE

Assessing changes in static and dynamic postural stability in youth football players following the FIFA 11+ injury prevention program

Évaluation des changements de stabilité posturale statique et dynamique chez les jeunes joueurs de football à la suite du programme de prévention des blessures FIFA 11+

R. Bahari Fard[a], A. Ebrahimi Atri[a,*], N.K. Khoshraftar Yazdi[a], B. Shahtahmassebi[a,b]

[a] *Department of Exercise Physiology and Sport Injuries and Corrective Movements, Faculty of Sport Sciences, Ferdowsi University of Mashhad, Mashhad, Iran*
[b] *Discipline of Exercise Science, Murdoch University, Perth, WA, Australia*

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KEYWORDS
Warm-up;
Single limb stance;
Time to stabilization;
Balance;
Neuromuscular control

Summary
Objective. — To examine the effect of FIFA 11+ warm-up program on static and dynamic postural stability in football players. Equipment and methods: Thirty young male football players (mean ± SD; age: 14.96 ± 0.76 years were recruited and divided into two groups (FIFA 11+ exercise group, $n = 15$ and control group, $n = 15$). The exercise group performed the FIFA 11+ injury prevention exercises as part of their warm-up and the control group continued their traditional warm up routines. The FIFA 11+ exercises were performed three times a week, for eight weeks. A single leg test with eyes closed, on a force platform, was used to measure static postural stability measurement, and time to stability after single leg drop-landing test was used for dynamic postural stability measurement.

* Corresponding author at: Department of Exercise Physiology and Sport Injuries and Corrective Movements, Faculty of Sport Sciences, Ferdowsi University of Mashhad, Mashhad, Iran.
E-mail address: atri@um.ac.ir (A. Ebrahimi Atri).

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Results. — The repeated measures (Anova) showed that the experimental group performed significantly better (adjusted mean difference [95% CI] or percentage %) in static postural stability (center of pressure displacement in the anterior-posterior direction [0.03 (95% CI 0.003 to 0.06), 8.56%] and medial-lateral [0.05 (95% CI 0.02 to 0.08), 9.19%]), and in dynamic postural stability (time to stability in the anterior-posterior direction [0.64 (95% CI 0.09 to 1.2), 15.82%] and medial-lateral [0.6 (95% CI 0.01 to 1.2), 18.92%]), compared with the control group. In conclusion, The FIFA 11+ injury prevention program may improve static and dynamic postural stability.

MOTS CLÉS
Échauffement ;
Position d'un membre ;
Temps de stabilisation ;
Équilibre ;
Contrôle neuromusculaire

Résumé
Objectif. — Examiner l'effet du programme d'échauffement FIFA 11+ sur la stabilité posturale statique et dynamique des joueurs de football.
Matériel et méthodes. — Trente jeunes footballeurs masculins (moyenne ± ET; âge : 14,96 ± 0,76 ans ont été recrutés et répartis en deux groupes (groupe d'exercice FIFA 11+, $n = 15$ et groupe témoin, $n = 15$). Le groupe d'exercice a effectué les exercices de prévention des blessures FIFA 11+ dans le cadre de son échauffement et le groupe témoin a poursuivi ses routines d'échauffement traditionnelles. Les exercices FIFA 11+ ont été effectués trois fois par semaine, pendant huit semaines. Un seul membre se tient avec les yeux fermés de la plaque de force a été utilisée pour la mesure de stabilité posturale statique, et le temps de stabilité après le test d'atterrissage sur une jambe a été utilisé pour la mesure de stabilité posturale dynamique.
Résultats. — Les mesures répétées (Anova) ont montré que le groupe expérimental obtenait des résultats significativement meilleurs (différence moyenne ajustée [CI 95 %] ou pourcentage %) en stabilité posturale statique (centre de déplacement de pression dans le sens direction antéro-postérieur [0,03 (CI 95 %) 0,003 à 0,06), 8,56 %] et médio-latérale [0,05 (CI à 95 % 0,02 à 0,08), 9,19 %]), et en stabilité posturale dynamique (temps de stabilisation dans la direction antéro-postérieure [0,64 (CI à 95 %) 0,09 à 1,2), 15,82 %] et médio-latérale [0,6 (CI à 95 % 0,01 à 1,2), 18,92 %]), par rapport au groupe témoin. En conclusion, le programme de prévention des blessures FIFA 11+ peut améliorer la stabilité posturale statique et dynamique.

1. Introduction

Football is one of the most popular sports in the world [1]. Like other sports, there is risk of injuries in football, in any ages and levels [1]. Epidemiological studies have shown that about 15 to 20 injuries (contact and non-contact injuries) were recorded for each 1000-hour gameplay and most of the injuries (about 60—90%) occurred in the lower limb, especially in the ankle, knee and groin [2]. A French epidemiological study has reported that about 618 injuries occurred over three years in 12—20 aged football players [3]. Recognition and prevention of injuries is thus highly important.

International Federation of Association Football (FIFA) Medical and Research Centre (F-MARC) designed ''the 11+'' warm-up program for football players [4]. The 11+ program is an advanced version of the ''11+'' [4]. It includes resistance, neuromuscular, balance, plyometric and agility exercises [5]. Previous studies have shown that the FIFA 11+ program had a significant effect on lower limb injury reduction in football players [6]. For example, Soligard et al. demonstrated that the FIFA 11+ injury prevention program reduces the risk of severe injuries, overuse injuries, and injuries overall in young female football players [6]. In another study, Silvers-Granelli et al. reached to this conclusion that the FIFA 11+ injury prevention program can significantly reduce injury rates by 46.1% and decreased time loss to injury by 28.6% in the competitive male collegiate football player [7].

It has been also shown that adequate static and dynamic postural stability is crucial in football playing [8]. Static postural stability or maintaining the center of mass over a stationary base of support may be assessed by single limb stance test [9]. Dynamic postural stability comprises maintaining the center of mass over the base of support when the base of support is moving or when an external perturbation is applied to the body and may be assessed by time to stabilization after single leg drop-landing test [10]. During the movement, body positions are controlled by displacements of the center of mass and the start of appropriate responses to return the body to a stable position, a complex process in which visual, vestibular and musculoskeletal systems play an important role [11]. Athletes with poor dynamic and static postural stability are more likely to be injured [12]. Specifically, football players with poor postural stability had increased prevalence of ankle injuries [13,14]. Incorporating a comprehensive injury prevention program such as FIFA 11+ into traditional football warm-up routines may possibly improve static and dynamic postural stability however this merits further exploration [15]. Thus, the present study aimed to examine whether the FIFA 11+ program will improve postural stability of youth male football

players. We hypothesized that youth male football players who have participated in the FIFA 11+ program will have improved stability compared to those who have not participated in the FIFA11+ program (control group).

2. Materials and methods

2.1. Design

This was a quasi-experimental study with pre-post cohort design. Independent variables included static and dynamic postural stability. Anticipating power analysis disclosed 30 participants would be required to detect a small-moderate effect (f = 0.29; type I error = 0.05; type II error = 0.80) between two groups assuming two repeated measurements with a correlation between measures of 0.50 and an anticipated 20% dropout rate. The effect size was computed from changes in static postural stability following the FIFA 11+ training intervention [16]. All participants were informed of the study procedures, and provided written informed consent prior to the commencement of the study. The present research was approved by the Biomedical Research Ethics Committee of Ferdowsi University of Mashhad, Iran (Protocol No: IR.MUM.FUM.REC.1397.025).

2.2. Participants

Thirty participants (mean ± standard deviation; age: 14.96 ± 0.76 years, height: 168.23 ± 6.17, body mass: 53.78 ± 9.63, body mass index: 18.91 ± 2.59) were recruited from amateur players of Mashhad amateur football league and divided into two groups (FIFA 11+ exercise group, $n = 15$ and control group, $n = 15$). Participants must have at least three years' experience playing football at an amateur level with regular training and without any history of major lower limb injuries and/or balance deficit. These teams generally play one matches per week and have three training sessions per week.

2.3. Procedures

The FIFA 11+ exercise group performed the FIFA 11+ injury prevention program as their warm-up, and then continued their usual training (Table 1). The FIFA 11+ is a structured program that contains cardiovascular, neuromuscular, balance, agility and plyometric exercises. This program has three parts. The first part (8 minutes) consists of six sessions, and the main goal of this part is to increase the heartbeat of the players and educate them on running, landing and jumping. The second part of the program (10 minutes) consists of six exercises focusing on the strengthening of the core muscles and legs, and increasing balance and explosive power. Each of the exercises in this section has three levels of difficulty. All players in the FIFA 11+ exercise group initially performed first level exercises in the first three weeks, then increased to the second level in weeks 4—5, and finally to the third level in weeks 6—8. The increase of level was done according to players' progress. The third part of the program involved medium and high speed running exercises with redirection for two minutes [6]. The control group performed their usual warm up exercises (Table 1). Each session started with five minutes running at a self-selected pace in order to increase heart rate. Secondly, dynamic exercises included hip in, hop out, lunge walk, knee to chest, and heel to glute were performed in 8 minutes. Moreover, static stretching exercises were performed for about 8 minutes. Finally, the program was finished by fast running exercise that lasted about four minutes. Both groups performed their exercises three times each week for eight weeks.

2.4. Dominant leg determination

Given that most studies reported more injury to a dominant leg rather than to the non-dominant leg [17], the dominant leg was tested in this study. The greater involvement of the dominant leg when shooting, tackling and jumping may be the cause of more damage in the dominant leg [17]. We have to mention that according to previously published studies, dominant leg is identified as the most often used leg for the technical movements and maneuvers such as dribbling, passing, and hitting the ball in soccer [18,19]. This results in an asymmetrical development of motor patterns, which can in turn lead to strength imbalance and can result in an increased risk of the dominant leg injury in soccer [18,19]. Read et al. have reported that leg dominance and leg asymmetry relate to increased risk of injury; a difference of 15% or greater, between an individual's dominant and non-dominant limb, has been shown to predict future injury [20]. The dominant leg selection was conducted by three functional tests, namely the shooting ball test (the foot that a person used to shoot), climbing test (the foot used to climb stairs), and balance recovery test (the foot used to recover disrupted balance) [21].

2.5. Static postural stability testing

To evaluate the static postural stability, single limb stance on force plate test was used [22]. The subject stood on one leg (dominant leg) with eyes closed on a Kistler force plate at 200 Hz sampling rate. The knee angle of the other leg of the subject was 45 degrees and the hip angle was 30 degrees, and the person's hands were placed on the chest crosswise. The subject repeated the test 3 times; each trial is 10 seconds with 30 seconds rest between each trial. Trials were discarded and recollected if the participant's non-stance limb touched the stance limb or the ground around the force plate or they cannot maintain their balance in 10 seconds. The mean of center of pressure (COP) changes was calculated in both anterior-posterior (AP) and medial-lateral (ML) directions [9]. To maintain the reliability of measurements, the center of the force plate was marked. To reduce the noise, a low-pass Butterworth filter with a cut-off frequency of 20 Hz was used [9,23]. The postural sway index, including the mean COP changes in AP and ML directions, was considered as the index of static postural stability. The calculation of the mean COP changes in the AP and ML directions was performed using the following formula in Excel software (Fig. 1). Average values of three times the repetition were used as the amount used in the calculations [24].

Table 1 FIFA 11+ warm up and usual warm up exercises.

FIFA 11+ warm up exercise			Usual warm up exercise		
Part1	Running exercise	Sets	Part1	Running exercise	Sets
1	Running, straight ahead	2	1	Running with self-selected pace	1
2	Running, hip out	2	2	Running, hip out	1
3	Running, hip in	2	3	Running, hip in	1
4	Running, circling partner	2	4	Lunge walk	1
5	Running, jumping with shoulder contact	2	5	Knee to chest	1
6	Running, quick forwards and backwards	2	6	Heel to glute	1
Part2	Strength, plyometric and balance exercises		Part2	Stretching exercise	
7.1	The bench, static	3	1	Standing bent-knee hip adductor stretch left	2
7.2	The bench, alternate legs	3	2	Standing bent-knee hip adductor stretch right	2
7.3	The bench, one leg lift and hold	3	3	Seated hip adductor stretch	2
8.1	Sideways bench, static	3	4	Standing one-leg knee to chest left	2
8.2	Sideways bench, raise and lower hip	3	5	Standing one-leg knee to chest right	2
8.3	Sideways bench, with leg lift	1	6	Standing knee flexor stretch left	2
9.1	Nordic hamstring, beginner	1	7	Standing knee flexor stretch right	2
9.2	Nordic hamstring, intermediate	1	8	Standing knee extensor stretch left	2
9.3	Nordic hamstring, advanced	2	9	Standing knee extensor stretch right	2
10.1	Single-leg stance, hold the ball	2	10	One-leg kneeling knee extensor stretch left	2
10.2	Single-leg stance, throwing ball	2	11	One-leg kneeling knee extensor stretch right	2
10.3	Single-leg stance, test your partner	2	Part3	Running exercise	
11.1	Squats, with toe raise	2		Fast running	1
11.2	Squats, walking lunges	2			
11.3	Squats, one-leg squats	2			
12.1	Jumping, vertical jumps	2			
12.2	Jumping, lateral jumps	2			
12.3	Jumping, box jumps	2			
Part3	Running exercises				
13	Running, across the pitch	2			
14	Running, bounding	2			
15	Running, plant and cut	2			

$$\frac{\mathcal{F}}{n-1}\sum_{i=1}^{n-1}\sqrt{(COP_{(i-1)}-COP_{(i)})^2}$$

Figure 1 Centre of pressure displacement calculation. F = Sampling rate, N = Number of data collected in ten seconds, I = The sample number, COP = Center of Pressure.

2.6. Dynamic postural stability testing

In order to evaluate dynamic postural stability, the time to stabilization (TTS) was calculated after performing the jump-landing task [25]. To perform this task, 50% of the maximum jump height of the subject was calculated. The subject first stood at a distance of 70 cm from the center of the force plate, then jumped to the point where he could jump and touch the index above the top of the force plate with one hand on the same side of the dominant leg. This jump was repeated three times until maximum jump height was achieved. 50% of the maximum height of the subject was then calculated and the index was adjusted at that height. The subjects were then trained to place their foot 70 cm from the center of the force plate, jump with two legs, and touch the 50% maximal jump index with the hand on the same side with dominant leg, and land on the force plate with the dominant leg. Subjects were required to put their hands on their pelvis as they land on the force plate and stay 20 seconds without moving. If a subject hopped after landing or placed non-supported leg on the ground or lost his balance, that effort would be eliminated and repeated. Subjects were allowed to practice the jump-landing several times to get familiar with the conditions of the test. Each subject performed the jump-landing task three times and the best performance was considered for statistical analysis. In order to prevent fatigue, two minutes rest were given after each task [26].

The ground reaction force was recorded using a force plate from the moment the subject's foot was contacted on the force plate for 20 seconds with a sampling rate of 1000 Hz, along with the AP and ML directions. First, the noise data was removed using the Butterworth low-pass filter. Calculation of the TTS in the AP and the ML components and also the ground reaction force data for each jump, was analyzed by MATLAB software separately. To calculate the TTS, using the reaction force data, first than 15 to 20 seconds was considered. Then, the magnitude of all the data was obtained and the amplitude of the variation of ground reaction force was calculated in this time period and in AP and ML directions. The largest number of this period is equivalent to the horizontal line that is placed on the reaction forces.

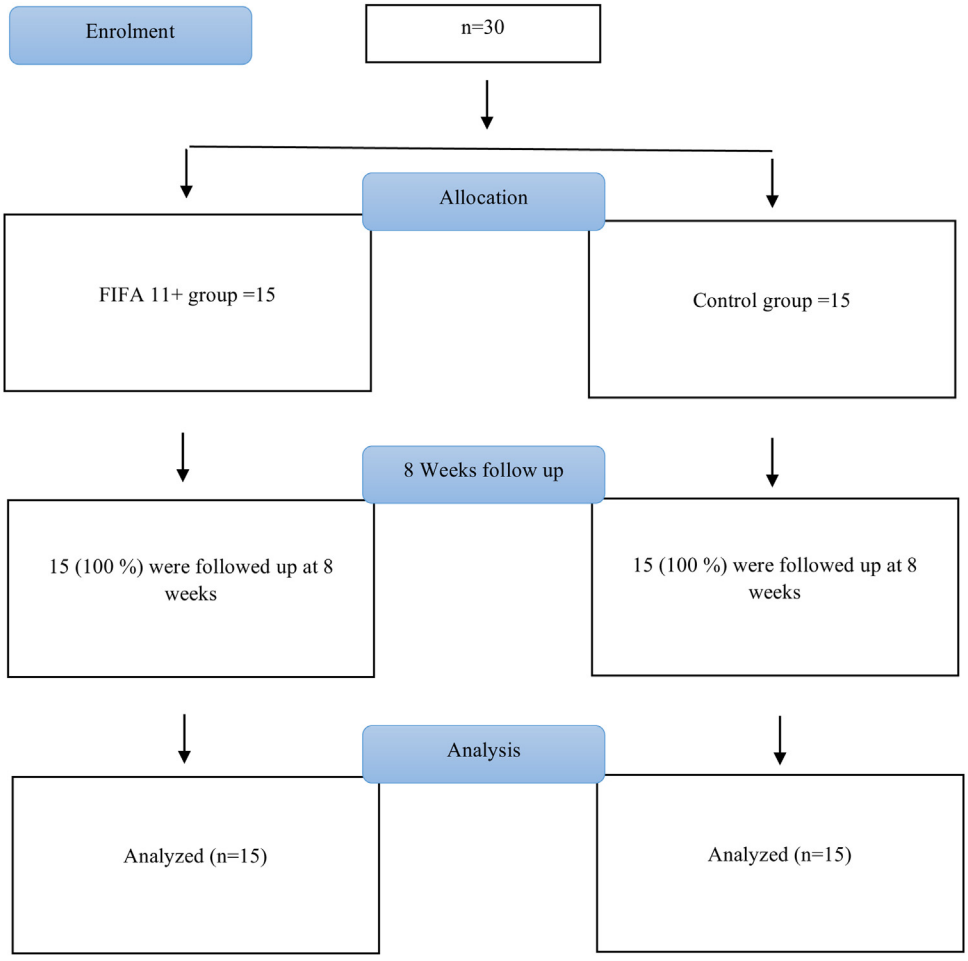

Figure 2 Study flow diagram.

In fact, this horizontal line represents the subject stability. Then the reaction force data was stratified and from the point of maximum reaction force, a third-order polynomial graph was placed on the components of the reaction force. The TTS in each of the components of the reaction force is the point where the polynomial graph breaks the horizontal line. The exact calculation of the TTS was performed in such a way that the third-order formula obtained from the three-degree polynomial graph equals the horizontal number, which placed on the reaction forces and by solving this third-order equation by the MATLAB, the exact TTS was calculated. To control the body mass variable, the reaction forces in both directions were divided in the body mass of the subject. The TTS was calculated at three times in both AP and ML directions, and then the mean time of the three tries as the TTS in that direction was considered [27].

2.7. Statistical analyses

For assessing the normality of groups distribution the Shapiro-wilk test was used. The Levene test was used to evaluate groups homogeneity in pre-test. Paired-sample *t*-tests were used for within group comparisons, from pre-test to post-test, and between-group changes after training in dynamic and static postural stability measures were evaluated using repeated-measures Anova. Statistical analysis was performed using SPSS software version 21 and $P<0.05$ was considered as statistically significant.

3. Results

Fig. 2 illustrates the recruitment and study flow process. All participants in the experimental (The FIFA 11+) and control groups participated in 24 training sessions. We did not have any dropouts, training, test-related injury or other adverse events. There were no significant differences in baseline measurements between two groups (Table 2).

The FIFA 11+ group experienced significant decreases (adjusted mean difference [95%CI] or percentage %) in AP displacement of the COP [0.03 (95% CI 0.003 to 0.06), 8.56%] and ML displacement of the COP [0.05 (95% CI 0.02 to 0.08), 9.19%] after 8-week intervention (Table 3). The FIFA11+ group showed large effect sizes in AP displacement of the COP [d = 0.97 (95% CI −1.72 to −0.21)], and ML displacement of the COP [d = 1.31 (95% CI −2.1 to −0.52)] (Table 3). Within-group analyses showed that there was a significant decrease in AP [0.03 (95% CI 0.008 to 0.4)] and ML displacement of the COP [0.01 (95% CI 0.007 to 0.05)] in the FIFA11+ group.

Table 2 Baseline characteristics of study's participants and time exposure.

Characteristics	FIFA 11+ group ($n=15$)	Control group ($n=15$)	P
Age, y[a]	15.06 ± 0.79	14.86 ± 0.74	0.48
Height, cm[a]	168.53 ± 6.46	167.93 ± 6.08	0.79
Body mass, kg[a]	55.8 ± 11.7	51.76 ± 6.82	0.25
Leg dominance[b]			
Left side	5 (33.3)	4 (26.7)	0.7
Right side	10 (66.7)	11 (73.3)	0.75
Exposure[a]			
Weekly soccer training, h	6.06 ± 0.79	6.2 ± 0.77	0.64
Weekly individual training, h	1.26 ± 0.77	1.53 ± 0.66	0.32
Weekly match exposure, min	55.66 ± 27.57	60.66 ± 28.02	0.62

[a] Values are presented as mean ± SD.
[b] Values are presented as number of player (%).

Table 3 Changes[a] in static and dynamic postural stability in response to FIFA 11+ exercise program.

Outcome measures, unit (group X time interaction: P-values)	FIFA 11+ group ($n=15$)	Control group ($n=15$)	Mean between-group difference (95%CI): FIFA 11+ vs. control group	P-values	Effect size
Static postural stability A/P (cm) ($P=0.04$)					
Baseline	0.32 ± 0.05	0.33 ± 0.02	0.007 (−0.24 to 0.03)	0.65	
8 weeks	0.29 ± 0.05	0.33 ± 0.03	0.03 (0.003 to 0.06)	0.03	0.97
Mean difference (95% CI): baseline vs. week 8	0.03 (0.008 to 0.4)	0.001 (−0.2 to 0.2)			
Static postural stability M/L (cm) ($P=0.05$)					
Baseline	0.32 ± 0.03	0.34 ± 0.03	0.02 (0.001 to 0.05)	0.04	
8 weeks	0.29 ± 0.05	0.34 ± 0.02	0.05 (0.02 to 0.08)	0.002	1.31
Mean difference (95% CI): baseline vs. week 8	0.01 (0.007 to 0.05)	0.81 (−0.2 to 0.2)			
Dynamic postural stability A/P (cm) ($P=0.22$)					
Baseline	3.9 ± 0.7	3.78 ± 0.79	−0.12 (−0.68 to 0.44)	0.66	
8 weeks	3.28 ± 0.76	3.93 ± 0.7	0.64 (0.09 to 1.2)	0.02	0.88
Mean difference (95% CI): baseline vs. week 8	0.61 (0.7 to 1.16)	−0.15 (−0.69 to 0.38)			
Dynamic postural stability M/L (cm) ($P=0.005$)					
Baseline	4.23 ± 0.57	4.11 ± 0.6	−0.12 (−0.56 to 0.31)	0.56	
8 weeks	3.43 ± 0.8	4.04 ± 0.78	0.6 (0.01 to 1.2)	0.04	0.77
Mean difference (95% CI): baseline vs. week 8	0.8 (0.38 to 1.21)	0.07 (−0.34 to 0.48)			

[a]Values are presented as mean ± SD or as adjusted mean difference (95% CI).

There was a significant decrease in TTS after single leg drop-landing in AP [0.64 (95% CI 0.09 to 1.2), 15.82%] and ML [0.6 (0.01 to 1.2), 18.92%] directions (Table 3). The FIFA11+ group demonstrated large effect sizes in TTS in AP [d = 0.88 (95% CI −1.63 to −0.13)] and ML [d = 0.77 (95% CI −1.51 to −0.03)] directions (Table 3). Within-group analyses showed that there was a significant decrease in TTS after drop landing in AP [0.61 (95% CI 0.7 to 1.16)]

and ML [0.08 (95% CI 0.38 to 1.21)] directions in the FIFA11+ group.

4. Discussion

This study investigated the effect of the FIFA 11+ prevention program on static and dynamic postural stability in youth male football players. Eight weeks of the FIFA 11+ training resulted in: 1) a significant improvement in static postural stability and 2) a significant improvement in dynamic postural stability when compared to the control group.

We found 8.56% and 9.19% decrease in COP displacement in A/P and M/L respectively in the FIFA 11+ group. This decrease in COP displacement can increase static postural stability and reduce risk of ankle injury [28]. The result of this study is consistent with Lee et al., who concluded that static postural stability significantly improved after twelve weeks balance board exercises. Retraining of the proprioception system and the improvement of the function of mechanical receptors and enhancement of neuromuscular coordination are the most important adaptations that they mentioned [29]. Closed-kinetic chain exercises stimulate the ankle mechanical receptors more than other parts of the body; it causes improving function of ankle mechanical receptors and increasing neuromuscular control. The FIFA 11+ training program is a closed kinetic type program and stimulates the mechanical receptors of joints and ankle muscles [29]. Improvement in muscle control is the most important point in static postural stability [30]. Studies have shown that neuromuscular exercises increase subconscious motor responses by stimulating the afferent signals as well as central mechanisms that responsible for maintaining balance [31].

We also found 15.82% and 18.92% decrease in time to stabilization after single leg drop-landing in A/P and M/L, respectively in FIFA 11+ group, which implies an increase in dynamic postural stability [32]. Proprioceptive exercises enhance the mechano-receptors of the lower limbs and improve neuromuscular control leg dominance, which ultimately leads to improved dynamic postural stability [31]. Impellizzeri et al. also reported significant improvements in dynamic postural stability after nine weeks of FIFA 11+ program in male amateur players (mean age = 23.7 ± 3.7) [33]. Ross and Guskiewicz also showed that dynamic coordination exercises performed on unstable surfaces such as foam and balance boards improve the dynamic postural stability in people with functional ankle instability [34]. We utilized time to stabilization test since it involves balance, postural control, mechanical and reactive stability and proprioception [33]. The FIFA 11+ training program includes a variety of exercises that enhance core stability, balance and postural stability, and this may lead to decrease in TTS after drop landing.

The FIFA 11+ program involves strengthening exercises like squats and lunges, and these can help improve muscle strength around the thigh, knee, and ankle, eventually increasing dynamic postural stability too. In fact, increasing muscle strength in the lower extremity can increases the dynamic and static stability of athletes [35]. Strengthening exercises for core stability muscles in the FIFA 11+ program, such as bench and side bench, can help to enhance strength and to build a stable base of support in movements such as jump-landing, and subsequently reducing the TTS. Furthermore, a gradual increase in the intensity and severity of the exercises and the increase in the number of repetitions can be effective in improving neuromuscular control and performing a single-leg jump-landing test. In addition to increasing the strength of the lower extremity muscles, increasing in proprioception, neuromuscular control and muscle co-contraction are other objectives of the 11+ training that can affect the dynamic and static postural stability of the players.

This study presented had multiple strengths, including (a) Adoption of reliable and valid postural stability measurement using the force plate; (b) Adoption of the FIFA 11+ program as a well-established and effective warm-up program for preventing injuries in football. Despite these strengths, this study has a number of limitations. First, this study was not a randomized control trial and none of the researchers were blinded to the study protocol. Secondly, this study did not incorporate any long term (> 8 weeks) of the effect of FIFA 11+ exercise program on static and dynamic postural stability thus the impact of these programs over longer periods is unknown. Furthermore, there is a limitation to the generalizability of the present study. Given the biomechanical differences between men and women, the results cannot be attributed to women. Future studies should thus focus on the long term (> 8 weeks) of the effect of FIFA 11+ exercise program on different physical and functional performance variables in youth male and female football players using randomized control trials designs. In addition, the benefits of the FIFA 11+ in other athletic populations (e.g., females, kids, elite/non elite, injured athletes) or other sports that have similar movement patterns to football (e.g., Futsal, Handball, Basketball, Volleyball) require further investigation.

5. Conclusions

Overall, the inclusion of the FIFA 11+ warm up exercises into the football training routines compared to the traditional football warm-up exercises improved postural stability which can be associated with a reduction in football injuries risk among young football players.

Disclosure of interest

The authors declare that they have no competing interest.

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References

[1] Barengo N, et al. The impact of the FIFA 11+ training program on injury prevention in football players: a systematic review. Int J Environ Res Public Health 2014;11(11):11986—2000.

[2] Faude O, Rößler R, Junge A. Football injuries in children and adolescent players: are there clues for prevention? Sports Med 2013;43(9):819—37.
[3] Tourny C, et al. Epidemiologic study of young soccer player's injuries in U12 to U20. J Sports Med Phys Fitness 2014;54(4):526—35.
[4] Thorborg K, et al. Effect of specific exercise-based football injury prevention programmes on the overall injury rate in football: a systematic review and meta-analysis of the FIFA 11 and 11 + programmes. Br J Sports Med 2017;51(7):562—71.
[5] Brito J, et al. Isokinetic strength effects of FIFA's''The 11 +'' injury prevention training programme. Isokinet Exerc Sci 2010;18(4):211—5.
[6] Soligard T, et al. Comprehensive warm-up programme to prevent injuries in young female footballers: cluster randomised controlled trial. BMJ 2008;337:a2469.
[7] Silvers-Granelli H, et al. Efficacy of the FIFA 11+ injury prevention program in the collegiate male soccer player. Am J Sports Med 2015;43(11):2628—37.
[8] Bieć E, Giemza C, Kuczyński M. Changes in postural control between 13-and 19-year-old soccer players: is there a need for a specific therapy? J Phys Therap Sci 2015;27(8):2555—7.
[9] Sell TC. An examination, correlation, and comparison of static and dynamic measures of postural stability in healthy, physically active adults. Phys Therap Sport 2012;13(2):80—6.
[10] Guskiewicz KM, Perrin DH. Research and clinical applications of assessing balance. J Sport Rehabil 1996;5(1):45—63.
[11] Nagy E, et al. Postural control in elderly subjects participating in balance training. Eur Journal Appl Physiol 2007;100(1):97—104.
[12] Jlid MC, et al. Multidirectional plyometric training: very efficient way to improve vertical jump performance, change of direction performance and dynamic postural control in young soccer players. Front Physiol 2019;10:p1462.
[13] Ekstrand J, Tropp H. The incidence of ankle sprains in soccer. Foot & ankle 1990;11(1):41—4.
[14] Hrysomallis C. Relationship between balance ability, training and sports injury risk. Sports Med 2007;37(6):547—56.
[15] Pomares-Noguera C, et al. Training effects of the FIFA 11+ kids on physical performance in youth football players: a randomized control trial. Front pediatr 2018;6:p40.
[16] Daneshjoo A, et al. The effects of comprehensive warm-up programs on proprioception, static and dynamic balance on male soccer players. PloS One 2012;7(12):pe51568.
[17] Huebscher M, et al. Neuromuscular training for sports injury prevention: a systematic review. Med Sci Sports Exerc 2010;42(3):413—21.
[18] DeLang MD, et al. The dominant leg is more likely to get injured in soccer players: systematic review and meta-analysis. Biol Sport 2021;38(3).
[19] Thompson R, Watson T. Is a professional soccer player's dominant lower limb at higher risk of injury than their non-dominant lower limb? A systematic review. Phys Ther Rev 2019;24(6):314—29.
[20] Read PJ, et al. Neuromuscular risk factors for knee and ankle ligament injuries in male youth soccer players. Sports Med 2016;46(8):1059—66.
[21] Hoffman M, Payne VG. The effects of proprioceptive ankle disk training on healthy subjects. J Orthop Sports Phys Ther 1995;21(2):90—3.
[22] Goldie PA, Bach T, Evans O. Force platform measures for evaluating postural control: reliability and validity. Arch Phys Med Rehabil 1989;70(7):510—7.
[23] Ghazaleh L, et al. Dynamics study of ankle joint during quiet standing balance control with emphasis on dominant and non-dominant lower limb. Phys Ther 2014;4(3):153—60.
[24] Karlsson A, Frykberg G. Correlations between force plate measures for assessment of balance. Clin Biomech 2000;15(5):365—9.
[25] Ross SE, Guskiewicz KM. Time to stabilization: a method for analyzing dynamic postural stability. Athlet Ther 2003;8(3):37—9.
[26] Gribble PA, Mitterholzer J, Myers AN. Normalizing considerations for time to stabilization assessment. J Sci Med Sport 2012;15(2):159—63.
[27] Webster KA, Gribble PA. Time to stabilization of anterior cruciate ligament—reconstructed versus healthy knees in national collegiate athletic association division I female athletes. J Athlet Train 2010;45(6):580—5.
[28] Trojian TH, McKeag DB. Single leg balance test to identify risk of ankle sprains. Br J Sports Med 2006;40(7):610—3.
[29] Lee AJ, Lin W-H. Twelve-week biomechanical ankle platform system training on postural stability and ankle proprioception in subjects with unilateral functional ankle instability. Clin Biomech 2008;23(8):1065—72.
[30] Clark VM, Burden AM. A 4-week wobble board exercise programme improved muscle onset latency and perceived stability in individuals with a functionally unstable ankle. Phys Ther Sport 2005;6(4):181—7.
[31] Coughlan G, Caulfield B. A 4-week neuromuscular training program and gait patterns at the ankle joint. J Athlet Train 2007;42(1):p51.
[32] Brown CN, Mynark R. Balance deficits in recreational athletes with chronic ankle instability. J Athlet Train 2007;42(3):p367.
[33] Impellizzeri FM, et al. Physiological and performance responses to the FIFA 11 + (part 2): a randomised controlled trial on the training effects. J Sports Sci 2013;31(13):1491—502.
[34] Ross SE, Guskiewicz KM, Yu B. Single-leg jump-landing stabilization times in subjects with functionally unstable ankles. J Athlet Train 2005;40(4):p298.
[35] Hrysomallis C. Balance ability and athletic performance. Sports Med 2011;41(3):221—32.