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The effect of the FIFA 11+ injury prevention program on youth soccer players performance (systematic review)

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Abstract

Background: The FIFA 11+ program has been shown to be effective in improving physical fitness factors and preventing injuries in soccer players.

Aim: The purpose of this study was to review the effect of the FIFA 11+ injury prevention program on youth soccer players' performance.

Materials and Methods: Relevant articles were searched in Science Direct, PubMed, Scopus, PEDro, and Google Scholar using the keywords "FIFA 11+", "performance", and "youth". The search yielded 32 articles, of which 14 were shortlisted, and ultimately, four were selected for review.

Results: The reviewed articles have indicated that the FIFA 11+ program results in a significant improvement in various performance factors ($P < 0.05$). These studies demonstrated that the FIFA 11+ program enhances stability, knee flexor muscle strength, sprint performance, agility, Slalom Dribbling, and flexibility. However, no significant improvements were observed in long jump, vertical jump, VO_2max, balance, and lower extremity range of motion.

Conclusion: Studies suggest that the FIFA 11+ warm-up program is more effective than conventional warm-ups in enhancing performance. Therefore, based on the literature reviewed, the FIFA 11+ program is recommended to enhance muscle strength, flexibility, and agility, thereby reducing injury risk in youth football players.

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1. Introduction

Soccer is one of the most popular sports worldwide, with approximately 200,000 professional athletes and 270 million amateur players [1, 2]. Approximately 90% of soccer players are male, and youth players constitute 54.7% of the overall player population [3]. Good performance in football depends on having a reasonable level of mental, physiological, biomechanical, tactical, and technical factors [4]. Football places numerous demands on physical fitness. These include sudden increases and decreases in speed, rapid shifts in direction, and tasks such as jumping, landing, and tackling, all necessary to maintain control or secure possession of the ball [5].

Unfortunately, soccer is frequently associated with risks of musculoskeletal damage [6]. A statistical analysis of sports injuries over a 10-year period recorded 19,530 injuries among 17,937 recreationally active participants, with 35% occurring during soccer, making it the sport with the highest injury rate [7]. Children and adolescent players are more susceptible to sports injuries compared to other age groups, likely due to lower skill levels, reduced endurance, poorer coordination, and weaker muscles [8]. Progressively, methodologies to improve performance and diminish the chance of injury in soccer are the core of football analysts, coaches, and players' consideration [4].

The FIFA 11+ injury prevention program, introduced in 2006, is a warm-up protocol designed to reduce injury rates, especially among elite and amateur football players. It was developed by the FIFA Medical Assessment and Research Centre in collaboration with the Oslo Sports Trauma Research Center and the Santa Monica Orthopaedic and Sports Medicine Center [9, 10]. Moreover, this program is structured into three segments: running exercises, strength training, plyometric, and balance exercises, culminating in further running exercises.

The first segment comprises six exercises lasting 8 min each. These include forward running, sideways running with hip variations, circling with a partner, and controlled landings with shoulder contact. Part 1 ends in quick forward and backward running. Part 2 consists of three progressive levels of difficulty for each exercise. The exercises include static bench routines with alternate leg positions and leg lifts, static side bench exercises with hip movement variations, Nordic hamstring exercises at varying difficulty levels, single-leg stances with ball manipulations, squats progressing from toe raises to single-leg squats, and jumping drills advancing from vertical to lateral and box jumps over a 10-minute duration. Finally, Part 3 consists of three running exercises lasting 2 minutes, involving running across the pitch, high bounding steps, and directional changes (Table 1) [11].

While FIFA 11+ has a direct beneficial impact on the player performance, several studies have also shown positive effects of exercises used in the prevention protocols for injuries. For instance, Yalfani (2020) found that FIFA 11+ and FIFA 11+ kids programs have the potential to influence some factors associated with sports injuries. The 11+ Kids workouts increase physical fitness parameters including balance, jumping ability, and lower limb isokinetic strength while lowering the risk of injury. However, no significant effect was observed on performance in the plank, side plank, 20-yard sprint, Illinois agility test, sit-and-reach test, slalom dribbling, or standing long jump [12].

Table 1. FIFA 11+ prevention program

FIFA 11 + program (20 minutes)						
Part 1 Running exercise 8 min		**Part 2 Strength, plyometric, balance 10 min**			**Part 3 Running exercise 2 min**	
Running straight ahead	2 reps	The plank (the bench)	Level 1: Both legs	3*20-30 sec	Running over pitch	2 reps
			Level 2: Alternate legs	3*20-30 sec		
			Level 3: One leg lift	3*20-30 sec		
Running, hip out	2 reps	Sid plank (sideways bench)	Level 1: Static	3*20-30 sec		
			Level 2: Dynamic	3*20-30 sec		
			Level 3: With leg lift	3*20-30 sec		
Running, hip in	2 reps	Nordic hamstring	Level 1	2-5 reps		
			Level 2	7-10 reps		
			Level 3	12-15 reps		
Running, circling	2 reps	Single leg balance	Level 1: Holding a ball	3*20-30 sec each leg	Bounding run	2 reps
			Level 2: Throwing a ball with a partner	3*20-30 sec each leg		
			Level 3: Testing with partner	3*20-30 sec each leg		
Running and jumping	2 reps	Squats	Level 1: With heels raised	3*20-30 sec		
			Level 2: Walking lunges	3*20-30 sec		
			Level 3: Single-leg squat	3*20-30 sec each leg	Running and cutting	2 reps
Running, quick run	2 reps	Jumping	Level 1: Vertical jumps	2*30 sec		
			Level2: Lateral jumps	2*30 sec		
			Level 3: Box jumps	2*30 sec		

However, the study by Trajković et al. (2020) indicated that FIFA 11+ has elicited significant improvement in the Illinois agility test, sit-and-reach test, and standing long jump [13].

Although the FIFA 11+ program is designed for players over the age of 14, it has been shown to improve movement patterns, stability, and trunk muscle endurance in younger athletes [14]. In addition, exercises for youngsters aged 11 and older have not specifically focused on football-specific skills [15].

Zhou et al. (2022) reported a significant improvement in knee flexor strength, suggesting that the FIFA 11+ program enhances both isometric and isokinetic strength. This is likely due to the strength training exercises included in FIFA 11+, which can enhance muscle activation, hamstring- to-quadriceps (H/Q) ratio and motor unit recruitment [16].

Furthermore, implementing FIFA 11+ kids for 12 weeks increase muscle strength in children aged 11-12 years [14]. FIFA 11+ was also found to enhance the running ability of young soccer players, as evidenced by improved sprint performance. This is beneficial for explosive power, endurance, and neuromuscular control of the lower limbs [17].

Reis et al. (2013), in their research on the effect of the FIFA 11+ warm-up program on futsal player performance, found that the program improved quadriceps and hamstring strength. Furthermore, major differences were found in functional H/Q ratio for both limbs and significant improvements were observed in the 5-m and 30-m sprint, agility, and slalom

test. Balance improved for the non-dominant limb, with a decrease in the number of falls. The improvements in slalom test suggest that players performing the FIFA 11+ enhanced technical performance [18].

However, Lopes et al. (2018) did not demonstrate any significant improvement in sprint, flexibility, agility and jump performance after the FIFA 11+ in male amateur futsal players [19].

Therefore, the main purpose of this study was to analyze the training effects of the FIFA 11+ on several parameters of physical performance in young football players. We hypothesized that this new program would demonstrate beneficial and superior effects on physical performance compared to the conventional warm-up practices as they include specific and novel exercises designed to improve physical fitness.

2. Materials and Methods

A systematic search was conducted to investigate the effect of the FIFA 11+ program on the performance of football players aged under 19 years in recent years, particularly from 2015 to 2023.

2.1. Eligibility criteria

2.1.1. Inclusion criteria

Inclusion criteria for all studies were based on the population, intervention, comparison, outcome, and study design. The studies were included for the review if they met the following criteria:

- The full text of the articles must have been available.
- Articles must be written in English or Persian.
- Articles must be published in scientific journals and be randomized controlled trials (RCTs).
- Articles must evaluate only the effect of the FIFA 11+ program on performance.
- Articles must evaluate the FIFA 11+ warm-up program among football players under the age of 19.

2.1.2. Exclusion criteria

Exclusion criteria included:

- Studies that examined the FIFA 11+ program among athletes who were not involved in football.
- Studies that investigated injury prevention and rehabilitation programs.
- Articles in which full text have not been available or found.

2.2. Intervention

Studies investigating the effects of the FIFA 11+ warm-up program on football players were deemed eligible for inclusion in this review. Studies investigating the effects of the FIFA 11+ warm-up program compared to a conventional warm-up program were included in this review. Moreover, articles comparing the FIFA 11+ program to another warm-up program were also considered eligible for this review.

2.3. Information sources

To ensure the inclusion of recent studies, articles published before 2015 were excluded. Two independent reviewers (F.M. and N.T.) independently searched the following databases from 2015 to 2023 for relevant studies: Google Scholar, PubMed, Science Direct, Scopus and PEDro.

2.4. Search strategy

Search terms were combined using Boolean logic with keywords such as: “performance”, “FIFA 11+”, “youth”, “football” and “injury prevention”. Example search strategy: (“11+” OR “the 11+”, OR “the 11+ warm-up” OR “the 11+

program" OR "FIFA injury prevention program" OR "FIFA11+") AND ("football" OR "soccer" OR "futsal"). There were no study design limits and only studies published in Persian or English were included.

2.5. Selection process

The initial database search yielded 520 articles. Two independent reviewers (F.M. and N.T.) screened and removed duplicates and irrelevant articles. After removing duplicate and irrelevant papers, 32 articles were evaluated based on the inclusion and exclusion criteria, resulting in the selection of 14 articles for further evaluation. Finally, after reviewing and reading the full text of the articles precisely and completely, 4 randomized control trials were selected for the review (Figure 1) [13, 16, 20, 21].

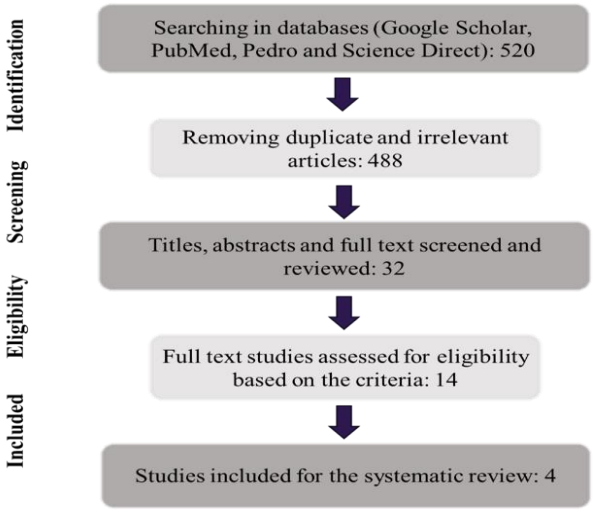

Figure 1. Data collection process chart

The two reviewers (F.M. and N.T.) extracted data from the selected articles using a self - designed data extraction form in Excel (Version 2019, Microsoft, and Redmond, WA, USA) Subsequently, the authors extracted the following data from the selected articles and imported them into a self-designed Excel file:

- The names and the impact factors of the journals,
- The performance parameters under review in the articles,
- The PEDro Scale score (),
- If the articles had specific inclusion and exclusion criteria,
- The age ranges.

The assessment of methodological quality involved the use of the PEDro scale for randomized controlled trials [22] (Table 2). Two authors were responsible for determining the score of each study using the PEDro scale, which comprises 11 items and assesses various aspects of study quality, with the first item focusing on external validity. Typically, this first item is not considered in the overall quality score. Consequently, the quality assessment in this study was based on items 2 to 11, following the guidelines established by Moher et al. [8]. A score of 1 was assigned for a "yes" response, and a score of zero for a "no" response. The studies were classified into three categories based on their scores on this scale: poor methodological quality for scores ranging from 0 to 4, moderate methodological quality for scores of 5 or 6, and high methodological quality for scores of 7 and above.

Table 2. PEDro scale for randomized studies

Pedro scale	Gatterer et al. (2018) [20]	Zhou et al. (2022) [16]	Trajković et al. (2020) [13]	Noguera et al. (2018) [21]
Eligibility criteria were specified	+	+	+	+
Random allocation of the subjects	+	+	+	+
Allocation was concealed	+	-	-	+
Groups similar at the baseline	+	+	+	+
There was blinding of all subjects	-	-	-	-
Blinding of therapists	-	-	-	-
Blinding of assessors	+	+	-	+
> 1 key outcome was obtained for more than 85% of subjects initially allocated to groups	+	+	+	+
All subjects received the treatment or control condition as allocated or, where this was not the case, data for at least one key outcome was analyzed by 'intention to treat'	-	-	-	-
Results of between-group statistical comparisons were reported for at least one key outcome	+	+	+	+
The study provided both point measures and measures of variability for at least one key outcome	+	+	+	+
Total score	7	6	5	7

3. Results

Following database searches and applying inclusion/exclusion criteria, 14 articles were analyzed, and ultimately, four were selected [13, 16, 20, 21]. The analysis included 4 studies conducted indifferent countries: 2 in Europe, 1 in Brazil, and 1 in Australia, between 2018 and 2022. Furthermore, the studies recruited adolescent male players, with a total of 98 participants across both intervention and control groups. All articles examined the impact of FIFA 11+ in intervention groups compared to conventional warm-up protocols in control groups on the performance of youth soccer players under 19 years of age. All studies performed an a priori sample size calculation to achieve a statistical power of at least 80% at a significance level of $P< 0.05$ for their primary outcome measures. This review presents, for each study, the author, participant demographics (gender and number), exercise protocol, and main results (Table 3).

3.1. Sprint

Three studies assessed changes in sprint speed following the implementation of the FIFA 11+ program [13, 16, 21]. Of these studies, two utilized the 20-meter sprint test, while one utilized the 30-meter sprint test. The study by Zhou et al. (2022) indicated a significant improvement in sprint speed [16]. However, the other two studies reported no significant beneficial effect on sprint performance [13, 21].

3.2. Agility

Regarding agility, two studies utilized the Illinois Agility test, while one study used the Shuttle Runs Test to evaluate agility. The studies by Noguera et al. (2018) [21] and Trajković et al. (2020) [13] demonstrated a significant improvement in agility as measured by the Illinois Agility Test. Similarly, the study by Zhou et al. (2022) indicated a significant improvement in agility using the Shuttle Run Test [16].

Table 3. Main aspects of references used in this study

Authors/years of publication	Methodological design	Number of subjects (N)	Groups comparison	Intervention protocol	Main results
Gatterer et al. (2018) [20]	Randomized control trial	16	Intervention group (n=8) Control group (n=8) Children aged < 14 years	Duration: 5 weeks Frequency: 2 times per week	Stability increased in both groups after 5 weeks of training with potentially better outcomes for the FIFA 11+ group. Standing long jump was not affected by either warm-up program.
Zhou et al. (2022) [16]	Randomized control trial	20	Intervention group(n=10) Age: 12.8 ± 1.9 years Control group (n=10) Age: 13.3 ± 0.17 years	Duration: 8 weeks Frequency: 3 times per week	Significant differences were found between the intervention group and the control group in agility, speed, knee flexor strength, knee extensor strength and also H/Q ratio as well.
Trajković et al. (2020) [13]	Randomized control trial	36	Intervention group (n=19) Age: 11.15±0.79 years Control group (n=17) Age: 10.87±0.8 years	Duration: 4 weeks Frequency: 3 times per week	Significant differences were found between groups in the standing long jump test and Illinois agility test. No significant difference was found between groups in speed, VO_2 max and RSA test.
Noguera et al. (2018) [23]	Randomized control trail	26 (23 Completed the study)	Intervention group (n=13) Control group (n=10) Age: 11.8± 0.3 years	Duration: 4 weeks Frequency: 2 times per week	Significant differences were found in agility and Slalom dribble. No significant differences were found in Y-Balance Test, ROM, 20 m sprint time, standing, drop jump and wall volley

3.3. Muscular strength on knee joint

Only one study examined knee joint muscle strength [16]. This study measured the isometric strength using a handheld dynamometer and observed that the knee flexor muscles strength improved significantly in the intervention group. However, the knee extensor muscles strength decreased slightly but significantly after the FIFA 11+ protocol. Moreover, the H/Q strength ratio increased significantly in the intervention group [16].

3.4. Flexibility

One study used a standardized sit-and-reach box to assess flexibility. The study revealed an improvement in flexibility in both the intervention and control groups [13].

3.5. VO_2max

Investigations by Trajković et al. (2020) indicated that VO_2max did not change significantly from pre- to post-test within the FIFA 11+ group [13].

3.6. Standing & Vertical jump

Three studies measured and evaluated the Standing Long Jump [13, 20, 21]. Of these, one study demonstrated a significant improvement [13], while the studies by Noguera et al. (2018) [21] and Gatterer et al. (2018) [20] showed no significant outcome in the Standing Long Jump measure. Additionally, Noguera et al. did not show any significant beneficial results for the Drop Jump and Counter Movement Jump tests (vertical jump) [21].

3.7. Abilities & Techniques

Regarding skills and techniques, Neguera et al. (2018) utilized two distinct and practical tests: The Slalom Dribble and the accuracy with Wall Volley test. Although the program did not significantly impact overall physical performance and skills, notable enhancements were observed specifically for the Slalom dribble test [21].

3.8. Stability

One study assessed stability using the MFT S3-Check system and observed that the FIFA 11+ group experienced a significant increase in stability [20].

3.9. Hip, knee, and ankle range of motion

In Neguera et al.'s study, the passive range of motion of the hip, knee, and ankle in both the dominant and non-dominant limbs was assessed. The study revealed potential beneficial effects in favor of the intervention group for knee flexion ROM. However, the effects for hip flexion and ankle dorsiflexion ROM were negligible [21].

3.10. Balance

Dynamic postural control was assessed using the Y-Balance Test [21]. Participants were allowed up to five attempts to achieve three successful trials for each reaching direction (i.e., anterior, posteromedial, and posterolateral directions). Promising results favoring the intervention group were noted in the Y-Balance Test, specifically in terms of the distance achieved in the anterior, posteromedial, and posterolateral directions, as well as the composite score [21] (Figure 2).

4. Discussion

This study aimed to systematically review research on the effectiveness of the FIFA 11+ warm-up program in enhancing youth football players' performance. The FIFA 11+ injury prevention program has been recommended and adopted worldwide, owing to its effectiveness and ease of implementation [24].

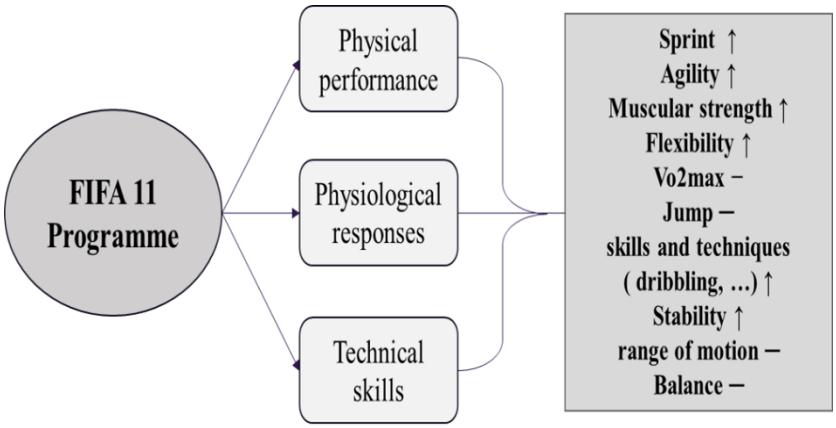

Figure 2. The benefits of FIFA 11+ injury prevention program. ↑ Increase, – without any change

Despite the proven effectiveness of the FIFA 11+ program, coaches and players often struggle to consistently implement it due to practical challenges.

A systematic review by Eslami et al. (2023) found that the FIFA 11+ program improved balance, isotonic strength, and lower extremity proprioception [25]. Moreover, a review by Mansueto Gomes Neto showed that FIFA 11 significantly reduces the rate of injury and increases dynamic balance and agility in football players [26].

Another systematic review and meta-analysis demonstrated that FIFA 11+ injury prevention program decreases the overall risk of injury and improves athlete performance parameters, such as agility and 20m sprint [27].

There is also evidence suggesting that the FIFA11+ has a positive long-term effect on H/Q strength ratios, agility, speed, static and dynamic balance and vertical jump performance. This review differs from previous systematic reviews in several methodological aspects. First, this review exclusively examined the effects of the FIFA 11+ program on the physical performance of youth players under 19. Second, we included 10 different and distinct performance factors in our research. Four randomized control trials were included in this systematic review, all of which demonstrated significant improvements in various performance parameters.

In the study conducted by Trajković et al. (2020), a group of 36 male youth football players aged 10-12 years were examined [13].

The findings suggest that implementing the FIFA 11+ warm-up twice a week for four weeks is sufficient to improve agility (Illinois Agility Test, 1.9%), flexibility (sit-and- reach), and explosive power (standing long jump, 5.6%). However, no significant improvements were observed in 20-meter sprint time, RSA parameters, or VO_2max. Similarly, Skoradal et al. (2018) found a significant enhancement in standing long jump, aligning with the findings of the Trajković et al. [28].

Conversely, the study by Zarei et al. (2018) demonstrated no significant improvement in sit –and- reach test after FIFA 11+ intervention. The lack of stretching exercises in this program is the most likely reason for the ineffectiveness of "the 11+ Kids" in improving flexibility [29].

In contrast, Impellizzeri et al. (2013) [10] and Zarei et al. (2018) demonstrated that FIFA 11+ exercises did not produce positive results for the Illinois agility test [29].

In contrast, Batool Mohammed Foqha et al. (2023) reported significant improvements in 20-meter sprint performance, contradicting previous findings [30]. Regarding VO_2max investigations by Rohmansyah et al. (2020) revealed that the FIFA 11+ protocol had no significant impact on the VO_2max, aligning with the findings of Trajkovi'c [31]. A key limitation of these studies is their short duration (four weeks), with no follow-up assessments to evaluate long-term effects. Additionally, as these studies focused solely on male players, the findings may not be generalizable to female athletes. Future research should investigate the effects of FIFA 11+ over longer durations and include more diverse populations. Furthermore, it is recommended that future studies explore the effects of the FIFA 11+ program over an extended period, utilizing a randomized control trial design, and examining various physical performance variables [13].

In the study by Pomares-Noguera et. al.'s, (2018) a total of 26 male youth football players (mean age: 11.8 ± 0.3 years; mean stature: 144.7 ± 5.1 cm; mean body mass: 39.4 ± 5.5 kg) participated in the study. Participants were recruited from two different football teams engaged in the Official Amateur Championships of the Spanish Football Federation (at a level lower than 12 years' regional league). The results obtained from the by Pomares-Noguera et al. suggest that the training stimuli provided through the implementation of the FIFA 11+ program for children, conducted twice a week over a period of 4 weeks (8 sessions in total), appear to be adequate in inducing minor to moderate enhancements in certain aspects of physical performance, specifically dynamic postural control, agility run, and jumping performance. However, these improvements were not observed in all parameters analyzed, including 20-m sprint time, slalom dribbling, wall volley test, and most ROM measures (except for knee flexion ROM) [21].

Zarei et al. (2018) [8], Sumartiningsih et al. (2022) [32], Teodorescu et al. (2023) [33], Liu (2021) [34], and Lotia et al. (2023) [35] have demonstrated a significant improvement (P<0.05) in dynamic balance following the implementation of the FIFA 11+ protocol, which aligns with the results reported by Pomares-Noguera et al.

Asgari et al. (2022) also observed significant enhancements in agility after the FIFA 11+ intervention [36].

Conversely, Parsons et al. (2019)_ found no improvement in agility following a nine-week intervention [37].

Regarding jumping performance (CMJ & DJ), the results of Akbari et al. (2018) [3] and Silva et al. (2015) [38] were consistent with Pomares-Neguera's investigations.

Daneshjoo et al. (2013) [39] and Asgari et al. (2022) [36] did not observe significant improvements in slalom dribble or Wall Volley test, aligning with previous research. Therefore, considering the intensity and volume of the FIFA 11+ program used in the study by Pomares-Noguera et al., it is possible that four weeks (8 sessions) may not be sufficient to elicit training responses in sprint times and football-specific coordination tasks (slalom dribbling and wall volley test [21]. The small sample size in each group (interventions or controls) is a significant limitation. Nevertheless, despite the enrollment of a limited number of participants in each group, notable main effects were identified. To mitigate the potential error arising from the control group imitating and executing any new exercise introduced in the intervention groups during their normal warm-up

routine, the players in the intervention groups performed their new warm-up in a distinct area of the field [21]. Additionally, a proficient rehabilitation specialist was assigned to each team to administer the interventions and ensure that the control groups refrained from engaging in exercises that were not part of their usual warm-up [21]. However, it is not entirely impossible to rule out that players in the control groups might have performed exercises included in the interventions outside of their regular training sessions [21]. Similarly, to prevent any possible bias in expectations from influencing the intervention and control groups, the participants were not provided with information regarding which warm-up program (FIFA11+ kids or traditional warm-up) was anticipated to yield superior outcomes in the dependent variables [21]. As previously mentioned, we cannot rule out the possibility that the participants may have sought information about the potential effects of the FIFA 11+ kids program on physical performance based on previous studies [21]. Nevertheless, neither the trainers nor any member of the research staff expressed any suspicion regarding this matter, thus we consider this potential source of bias to be insignificant. To gain a deeper understanding of the potential mechanisms underlying the reported decrease in injury incidence, as reported by the FIFA 11+ kids program, future studies should explore the effects of longer interventions (lasting more than 4 weeks) on various physical performance variables, utilizing randomized control trial designs [21].

In the investigation conducted by Gatterer et al. (2018), the impact of the FIFA 11+ warm-up program on the performance of 10-year-old soccer players was explored. The study focused on two variables: stability and standing long jump. The key findings of this study indicate that stability improved in both groups after five weeks of training, with a potentially greater improvements observed in the FIFA 11+ group [20].

However, the standing long jump performance was not influenced by either warm-up program. This study demonstrates that the FIFA 11+ program positively affects the stability of young athletes, which in turn enhances their performance and reduces the risk of injury [40]. Furthermore, implementing the FIFA11+ program for eight weeks led to a statistically significant enhancement in the overall stability index, while standing long jump performance remained unaffected by this specific program [20].

These results align with the findings of Pomares-Noguera et al. [21] but contrast with results from Kilding et al. [17], Rössler et al. [41], and Trajković et al. [13], who reported improved jump performance following the FIFA 11+ program. The discrepancy in outcomes between these studies may be attributed to differences in training volumes. In the current study, the program was conducted twice a week for five weeks during regular training sessions [20]. However, Kilding et al. implemented the FIFA 11+ program five times a week for six weeks [17], Rössler et al. used a ten-week program [41], and Trajkovic et al. conducted the program for four weeks with three sessions per week [13]. Therefore, the total training volume in these studies exceeded that of study by Gatterer et al. [20]. Additionally, the lack of specificity of the FIFA 11+ warm-up exercises for standing jump may contribute to the absence of improvement in this aspect [20].

Zhou et al. conducted a study over 8 weeks with a sample of 20 young football players and demonstrated that implementing the FIFA 11+ program led to

improved knee flexor strength. The effectiveness of the FIFA 11+ program in enhancing the isokinetic strength of the knee flexors in football players has already been established by previous research. However, this study specifically focused on measuring the impact of the program on the isometric strength of the knee flexors, and the findings indicated a notable increase in this aspect [16].

Several other studies have also provided evidence that consistent performance of the complete FIFA 11+ program can lead to enhanced knee flexor strength [10, 39, 42]. This positive effect is likely attributed to the inclusion of Nordic hamstring training in the FIFA 11+ program, particularly in its Part 2, which is considered a suitable training regimen for improving knee flexor strength and reducing sports-related injuries [16, 43].

In the context of strength training studies, the initial improvements in voluntary strength are primarily associated with neural adaptation, such as coordination and learning [43]. Furthermore, engaging in the FIFA 11+ program has been shown to have a positive impact on neuromuscular control [44].

The (H:Q) strength ratio, which compares the concentric peak net torque of the hamstrings with that of the quadriceps at a matched angular velocity, serves as a key determinant of knee injuries [45]. Maintaining a balance between the hamstrings and quadriceps muscles is crucial in this regard. In the present study, the H/Q ratio of the intervention group was significantly higher after the intervention, aligning with previous findings [16].

Arsenis et al. also observed statistically significant differences in the concentric strength of the rear thigh muscles and conventional H/ Q ratios of both lower limbs among players participating in the FIFA 11+ program [46]. These results are consistent with the conclusions by Brito et al., who stated that the 11+ training program is suitable and effective for football training and conditioning as it improves knee joint strength and muscle balance [47].

Similarly, Impellizzeri et al. found that the FIFA 11+ program, when performed three times a week for 9 weeks by a group of eighty-one players, led to enhanced strength balance in the knee flexor and extensor muscles of male soccer players [10]. Due to the specific demands of football, the quadriceps muscles are required to bear weight during vertical jump take-offs and landings [48]. As a result, the quadriceps muscles often become stronger than hamstrings [48]. As football players tend to have lower H/Q ratio than the average population [16, 39], this strength imbalance is a key risk factor for knee injury [45].

Zhou et al. found that the relative strength of the knee extensors in intervention (INT) group players, was significantly lower than pre-intervention test. While it did contribute to increasing H/Q ratio and is not considered a risk factor, decreases in knee extensor strength are certainly not the goal of the intervention [16].

The 30-meter sprint and 5 × 25-meter shuttle run are widely utilized performance indicators for soccer players [49]. The ability to execute high-speed running actions is a fundamental requirement for success in contemporary football [18, 50]. The current investigation demonstrated that the FIFA 11+ program can improve the running capability of young soccer players, particularly when compared to conventional warm-up exercises [16]. These findings are partly consistent with the

research by Nawed et al., who observed that a 12-week (5 sessions per week) FIFA 11+ training regimen significantly enhanced sprint speed in amateur male soccer players [51].

The outcomes of Hwang et al.'s study revealed that the FIFA 11+ training group exhibited improved performance in the 30-meter sprint, coordination, and agility with enhanced functional movement [52].

It appears that incorporating the Nordic hamstring curl in part 2 has contributed to the enhancement of sprint performance. The Nordic hamstring curl is an eccentric exercise that specifically targets the strengthening of the hamstrings in an eccentric manner [52].

5. Conclusions

The findings from this study indicate that the FIFA 11+ warm-up protocol can lead to significant improvements in various physical performance measures among youth football players. Specifically, the application of this program has been associated with enhancements in stability, knee flexor muscle strength, sprinting ability, agility, slalom dribble performance, and flexibility.

However, to build upon these results, further research is essential to evaluate the effects of the FIFA 11+ on joint range of motion, stability, and flexibility. Additionally, addressing the existing biases concerning its impact on vertical jump and standing long jump performance is crucial for a comprehensive understanding of its efficacy.

Based on these findings, the FIFA 11+ program should be integrated into training regimens to enhance muscle strength, flexibility, and agility. This may reduce injury risk and improve overall performance in youth football players. Future studies should continue to investigate these outcomes, ensuring that the program remains evidence-based and effective.

Conflict of interest

The authors declared no conflicts of interest.

Authors' contributions

All authors contributed to the original idea, study design.

Ethical considerations

The authors have completely considered ethical issues, including informed consent, plagiarism, data fabrication, misconduct, and/or falsification, double publication and/or redundancy, submission, etc.

Data availability

The dataset generated and analyzed during the current study is available from the corresponding author on reasonable request.

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