

# Investigation of the acute effect of different warm-up protocols on test performance in young soccer players

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## Abstract

**Background and Study Aim** Effective warm-up strategies are crucial for optimizing performance in team sports. However, identifying the most effective protocols requires consideration of the specific conditions and age of young athletes. The purpose of this study is to examine the acute effects of three different warm-up programs on specific test performance responses in young soccer players.

**Material and Methods** Twenty-three amateur soccer players (age =  $15.13 \pm 0.81$  years) participated in the study. The athletes performed a dynamic warm-up along with two different neuromuscular warm-up programs: the FIFA 11+ and the Injury Prevention and Performance Enhancement Program. Performance responses in sprint, jump, and agility tests were measured. Data normality was assessed with the Shapiro-Wilk test. The effects of the warm-up protocols were analyzed using one-way repeated measures ANOVA, with significance set at  $p < 0.05$ .

**Results** The research findings revealed a statistically significant difference in the 10m sprint, 20m sprint, vertical jump, and zig-zag agility tests, both with and without the ball, when using the FIFA 11+ warm-up program ( $p < 0.05$ ). The study demonstrated that the FIFA 11+ warm-up program improved performance responses more effectively than the other warm-up programs. This warm-up protocol enhances neuromuscular control by increasing the activation of the core, hip, and leg muscles.

**Conclusions** The study demonstrates that the FIFA 11+ warm-up program significantly enhances performance in specific tests, such as sprinting, jumping, and agility. Coaches are encouraged to implement the FIFA 11+ protocol in both training sessions and pre-match routines to optimize athletic performance in young soccer players.

**Keywords:** dynamic warm-up, FIFA 11+, soccer, agility, sprint

## Introduction

Performance optimization remains a major challenge in youth soccer. High-intensity actions often result in fatigue and increase the risk of injury. Despite the widespread use of warm-up routines, there is still uncertainty about which protocols are most effective for enhancing performance and reducing injury risk. Soccer is among the team sports with the most significant sports population in the world in terms of both the number of spectators and participants [1], and it also attracts great interest among children and young people under the age of 18 [2]. Performance in soccer depends on technical actions such as shooting, passing, dribbling, and various physical factors such as sprinting, jumping, and changing direction [3, 4, 5]. Such high-intensity activities heavily burden the aerobic and anaerobic energy systems and impose many physiological demands [1]. The risk of injury increases due to the physiological responses in the muscles after high-intensity movements involving speed, agility, and explosive power [6]. Therefore, sports scientists and coaches must design effective warm-up programs before training or matches to maximize performance [7, 8].

Warming up involves short-term, high-intensity activities that improve physical fitness by increasing intramuscular temperature, nerve conduction velocity, and metabolic reactions [9]. In the literature, warming up is generally recognized to have two main effects: 1) maximizing performance [10, 11, 12] and 2) reducing the risk of injury [8, 13, 14]. Numerous studies have highlighted the effectiveness of different types of warm-ups under specific conditions [15, 16]. Research has shown that muscle performance can increase by 3.46% to 4.21% following a specific warm-up [9, 17]. This emphasizes the need for a well-defined pre-match warm-up, tailored to the players' characteristics, such as age, skill level, experience, and training hours.

Although various warm-up methods are used in soccer, programs like FIFA 11+ and the Injury Prevention and Performance Enhancement Program (PEP) are becoming increasingly common [10, 18]. These programs, preferred as alternatives to traditional warm-up methods, typically include running, static and dynamic stretching [19], neuromuscular exercises for injury prevention, high-intensity performance drills, post-activation exercises, and tasks aimed at specific tactical goals [20, 21]. The goal of these warm-ups is to transition

from general activities to more game-specific tasks to improve performance [22]. Consequently, several variables related to warm-up should be considered. For example, studies that examine factors such as the duration [12] and intensity [23] of the warm-up before performance suggest that a short warm-up (around 8 minutes) is the most effective in increasing acceleration. However, other research argues that both short-term and long-term warm-ups are equally effective for repeated sprint performance [16,24].

Thus, the FIFA 11+ and PEP programs have demonstrated significant effectiveness in improving various aspects of athletic performance. However, an analysis of the studies indicates that contradictions remain regarding the optimal duration and intensity of warm-ups. Despite this, few studies have directly compared these programs, especially among young athletes. This highlights the need for additional research to determine the most effective warm-up protocols under specific conditions. The purpose of this study is to examine the acute effects of three different warm-up programs on specific test performance responses in young soccer

**Materials and Methods**

*Participants*

The sample group consisted of 23 amateur male soccer players (age = 15.13 ± 0.81 years, height = 168.86 ± 6.78 cm, weight = 54.95 ± 7.54 kg, BMI = 19.18 ± 1.52) who had been training regularly for at least three years and were playing for the same club. The study was conducted during the preparation period at the beginning of the season, when no matches were scheduled. Before the study, each player was provided with detailed information about the potential risks and discomforts related to the research. The “Voluntary Subject Information and Consent Form” was read and signed by both the players and their parents. The study was conducted in accordance with the Declaration of Helsinki and was approved by the University Ethics Committee.

*Research Design*

First, anthropometric measurements were taken of the soccer players participating in the study. On the first day, the athletes performed the sprint, jump, and agility tests in sequence following the dynamic warm-up. On the second day, the same tests were conducted after the FIFA 11+ warm-up protocol. Finally, on the third day, the athletes performed the tests again after the PEP warm-up protocol. A 48-hour rest period was given between each testing day.

*Data Collection Tools*

*Anthropometric Measurements.* Participants’ height, body weight, and Body Mass Index (BMI) were measured using the Tanita BC 418 professional body analysis scale (Tanita Corp of America, Inc,

USA). Measurements were taken in the morning, with participants in anatomical posture, barefoot, wearing only shorts, and on an empty stomach.

*10m-20m-30m Sprint Test.* Sprint distances of 10, 20, and 30 meters were marked on the soccer field. Photocell devices with a precision of 0.01 seconds were placed at these points for accurate measurement. Each soccer player performed two attempts, and the best score was recorded.

*Zig-Zag Agility Test.* A photocell device with a precision of 0.01 seconds was placed at the designated start and finish points on the soccer field for measurement. The agility test was performed both with and without the ball. Each soccer player was asked to complete two attempts, and the best score was recorded.

*Vertical Jump Test.* For the vertical jump test, a Microgate WITTY (Wireless Training Timer, Bolzano, Italy) jump mat was used to measure the jump height of the soccer players. Players began with bent knees, jumped to reach the highest vertical point possible, and landed back on the mat. Each player performed two attempts, with the best score recorded.

*Dynamic Warm-Up.* The dynamic warm-up consists of four parts, lasting a total of 25 minutes. The first part includes a 10-minute warm-up run. The second part consists of 6 minutes of dynamic movements. The third part involves 6 minutes of static flexibility exercises, and the fourth part concludes with 3 minutes of tempo runs (Table 1).

**Table 1.** Dynamic Warm-up

EXERCISES	Time	Set
<b>Section 1: Straight Running [Jogging]</b>		
Straight Running	5 min	1
<b>Section 2: Dynamic Warm-up Movements</b>		
Arm Circles Forward, Arm Circles Backward, Hip Circles Clockwise, Hip Circles Counterclockwise, Legs Inward, Legs Outward, Knee-to-Chest, Heels to Glutes	6 min	1
<b>Section 3: Static Flexibility Exercises</b>		
Trapezius Stretch, Shoulder Rotator Cuff Stretch, Calf Stretch, Quadriceps Stretch, Hamstring Stretch, Adductor Stretch	6 min	1
<b>Section 4: Pace Runs</b>		
Sprints	3 min	1
<b>Total</b>	<b>25 min</b>	

*FIFA 11+ Warm-Up Protocol.* The FIFA 11+ warm-up program consists of three parts and includes 15 different exercises (Table 2). The first part involves

stretching and running exercises with controlled partner contact. The second part focuses on balance, trunk and leg strengthening, plyometric exercises, and agility drills. The third part consists of medium- and fast-paced running exercises, incorporating changes of direction [20].

**Table 2.** FIFA 11+ Warm-Up Protocol [11]

EXERCISES	Set	Repeat	Time
<b>Section 1: Running Exercises</b>			
Straight Running, Hip Outward, Hip Inward, Partner Exchange, Shoulder-to-Shoulder, Forward-Backward	2	1	8min
<b>Section 2: Strength, Plyometric, and Balance Exercises</b>			
Plank: Static Plank, Plank with Alternating Legs, Single-Leg Plank	3	1	20-30sec
Side Plank: Proper Position on Arm and Foot	3	1	20-30sec
Hamstring Stretch: Beginner (3-5 sec), Intermediate (7-10 sec), Advanced (12-15 sec)	1	3-5	60sec
Single-Leg Balance: Static Ball Hold	2	1	30sec
Squat: On Toes	2	1	30sec
Jump: Vertical Jump in Place	2	1	30sec
<b>Section 3: Advanced Running Exercises</b>			
Pace Runs, Bounding Runs, Zigzag Runs	2	1	2min
<b>Total</b>			<b>20min</b>

*Injury Prevention and Performance Enhancement Program (PEP).* The PEP warm-up program was developed to prevent lower extremity injuries [25]. It consists of five sections, lasts approximately 20 minutes, and includes exercises designed for muscle activation, balance, and trunk stability (Table 3).

**Table 3.** PEP Warm-up Protocol [25]

EXERCISES	Time / Repeat
1	2
<b>Section 1: Warm-up</b>	
Jog Line to line (cone to cone)	45.5 m
Shuttle Run	45.5 m
Backward Running	45.5 m

**Table 3.** (Continued).

1	2
<b>Section 2: Flexibility</b>	
Calf stretch	2 reps x 30 sec
Quadricep stretch	2 reps x 30 sec
Hamstring stretch	2 reps x 30 sec
Inner Thigh Stretch	2 reps x 30 sec
Hip Flexor Stretch	2 reps x 30 sec
<b>Section 3: Strengthening</b>	
Walking Lunges	2 set x 18 m
Russian Hamstring	30 sec
Single Toe Raises	30 reps on each side
<b>Section 4: Plyometrics</b>	
Lateral Hops over Cone	30 sec
Forward/ Backward Hops over cone	30 sec
Single Leg hops over cone	30 sec
Vertical Jumps with headers	30 sec
Scissors Jump	30 sec
<b>Section 5: Agilities</b>	
Forward run with 3 step decelerations	35 m
Lateral Diagonal runs	35 m
Bounding run	40 m

### Statistical Analysis

Statistical analysis was conducted using SPSS version 26.0. Mean  $\pm$  standard deviation was used for descriptive analysis. The normality of the data was assessed using the Shapiro-Wilk test. The effects of the three different warm-up protocols on the performance tests were analyzed with a one-way repeated measures analysis of variance (ANOVA) for each performance variable. Statistical significance was set at  $p < 0.05$ . Effect sizes were evaluated using  $\eta^2$ , where  $0.01 < \eta^2 < 0.06$  indicates a small effect,  $0.06 < \eta^2 < 0.14$  indicates a medium effect, and  $\eta^2 > 0.14$  indicates a large effect [26].

### Results

Table 4 presents the analysis results of the three different warm-up protocols. According to the results, there was a statistically significant difference between the groups in the 10m sprint, 20m sprint, vertical jump, and zig-zag agility tests, both with and without the ball. The FIFA 11+ warm-up protocol consistently showed better results compared to the PEP and dynamic warm-up methods.

**Table 4.** Warm-up protocols and Test performance results

Test performance	Warm-up protocols			p	η <sup>2</sup>
	FIFA11+	PEP	Dynamic		
	$\bar{X} \pm SD$	$\bar{X} \pm SD$	$\bar{X} \pm SD$		
10m sprint	1.97 ± 0.10	2.00 ± 0.11	2.01 ± 1.0	0.000	.840
20m sprint	3.25 ± 0.13	3.28 ± 0.13	3.28 ± 1.13	0.000	.438
30m sprint	4.46 ± 0.22	4.48 ± 0.21	4.47 ± 0.21	0.215	.069
Vertical Jump	30.50 ± 4.77	30.21 ± 4.70	30.03 ± 4.72	0.007	.286
Zig-Zag Agility [with ball]	7.72 ± 0.26	7.73 ± 0.26	7.75 ± 0.27	0.016	.235
Zig-Zag Agility [without ball]	6.28 ± 0.14	6.32 ± 0.12	6.32 ± 0.15	0.000	.577

Note.  $\bar{X}$ : mean; SD: standard deviation;  $p < 0.05$ : significant value;  $\eta^2$ : partial eta square value

### Discussion

This study aimed to compare the acute effects of the neuromuscular warm-up protocols—FIFA 11+, PEP, and dynamic warm-up—on acceleration, sprint, jumping, and agility performances in male soccer players aged 14-16 years. The goal was to determine which of these warm-up methods is most effective in improving test performance times. The main finding of this study is that the FIFA 11+ warm-up protocol had a positive effect on 10m sprint, 20m sprint, vertical jump, and agility performances, both with and without the ball, in young soccer players.

There are numerous studies investigating the acute effects of dynamic, static, or combined warm-ups, which are commonly recommended to enhance athletic performance [19, 27, 28, 29]. Many of these studies have demonstrated that dynamic warm-ups have positive effects on performance [30], including improvements in sprint times [31], jump height [32], and agility [33]. For example, Needham et al. [34] examined the acute effects of three different warm-up protocols on anaerobic performance in young soccer players. These protocols included 5 minutes of low-intensity running followed by 10 minutes of either static stretching, dynamic stretching, or dynamic stretching combined with eight squats at 20% of body mass. Their findings showed that the dynamic warm-up protocol was more effective than the static protocol in improving anaerobic performance. These results align with recent studies, which suggest that dynamic stretching exercises in the warm-up phase enhance test performance compared to static stretching. Unlike static warm-ups, dynamic warm-ups are recommended as a pre-performance routine due to their acute enhancement of strength, sprint, and jumping performance [35]. However, there are relatively few studies that compare different dynamic warm-up methods while focusing specifically on physical performance. Most research in this area has concentrated on injury prevention programs, such as FIFA 11+ and PEP, rather than examining their direct effects on performance [10,36,37].

In this context, the results of our study align with previous research that highlights the positive effects of dynamic warm-ups on key performance indicators such as sprinting, jumping, and agility. Our findings, which demonstrate the effectiveness of the FIFA 11+ program, are consistent with those of Needham et al. [34] and Bizzini et al. [20], who also observed benefits from dynamic warm-ups in improving anaerobic and overall physical performance. However, unlike some other studies, such as the work by Impellizzeri et al. [43], our study observed more pronounced improvements in performance metrics following the FIFA 11+ protocol. This difference may be attributed to factors such as the age of the participants, the duration of the warm-up protocols, or other training-specific variables. Therefore, our study contributes to a deeper understanding of how different warm-up methods can impact the physical performance of young athletes.

In pre-performance warm-ups, various methods are applied to enhance key performance indicators such as speed, strength, and agility. Although the FIFA 11+ program was originally developed to prevent injuries, recent studies have shown that it can also improve the physical performance of soccer players [38]. Asgari et al. [10] conducted a systematic review that categorized the literature on the effects of the FIFA 11+ program into three main areas: performance, biomechanical measurements, and physiological responses. The first category includes studies on child players under 14 years old, the second focuses on adolescent and young players aged 14 to 20, and the third examines adult players over 20 years old. While the studies in the second category are most relevant to this study's sample group, the findings on performance parameters such as agility, vertical jump, balance, dribbling, and sprinting have been inconsistent.

Several studies have investigated the acute effects of different warm-up methods on speed, jumping, and agility test performances across various age groups. Two of these studies reported non-significant or even adverse immediate effects

on sprinting and agility when compared to dynamic warm-ups, which contrasts with the findings of our study [39, 40]. In contrast, Bizzini et al. [20] concluded that the FIFA 11+ warm-up method can be considered a suitable protocol, significantly improving speed and agility.

In comparison to previous research, our study's findings support the growing evidence that the FIFA 11+ program can positively impact physical performance, particularly in agility, sprinting, and jumping. While Asgari et al. [10] and other studies [39, 40] have reported inconsistent results, especially in young athletes, our study demonstrates clear benefits in these performance areas. Additionally, our results align more closely with those of Bizzini et al. [20], who observed significant improvements in speed and agility following the FIFA 11+ warm-up. The differences between these findings and those of earlier studies may be due to variations in participant age, training level, or the specific application of the warm-up protocols.

Similar to acute studies, chronic studies examining the effects of the FIFA 11+ warm-up protocol on performance responses have also shown conflicting results. When reviewing the sprint, vertical jump, and agility test performance responses in the literature, which are the performance parameters with significant differences in this study, there are studies that report positive effects of the FIFA 11+ warm-up protocol [38, 41, 42], as well as studies that show either negative effects or no effects at all [43, 44]. For example, Zarei et al. [42] reported that the FIFA 11+ program improved agility, vertical jump, and sprint performance among amateur U16 players during a soccer season. Similarly, Gok et al. [45] compared the effects of a general warm-up with the FIFA 11+ warm-up program on athletic performance and Functional Movement Screening (FMS) test scores in a study of 40 male soccer players aged 14-16. The group that followed the FIFA 11+ warm-up protocol showed improvements in 10m, 20m, and 30m sprint times, agility, vertical jump, balance, endurance, flexibility, and total FMS scores.

In contrast, Impellizzeri et al. [43] did not find similar results after applying the FIFA 11+ program to amateur players aged 21-25 over a nine-week period. However, this study aligns with recent research showing that the FIFA 11+ warm-up method enhances sprint performance [45], jumping performance [42], and agility [38]. This improvement is thought to result from the diverse components of the FIFA 11+ program, which combines various exercises such as balance, squats, and jumps. These exercises are believed to enhance neuromuscular control by increasing activation of the core, hips, and leg muscles. Additionally, the inclusion of exercises like the "Nordic hamstring curl" and plyometric drills may contribute to developing the stretch-shortening cycle, which is linked to

improved jumping performance.

In line with previous findings, our study confirms the positive effects of the FIFA 11+ program on key performance metrics, such as sprinting, agility, and vertical jump, as observed by Zarei et al. [42] and Gok et al. [45]. These results contrast with studies like Impellizzeri et al. [43], which reported no significant performance improvements after applying the FIFA 11+ program to older athletes. The conflicting outcomes across different studies may be explained by factors such as the age group of participants, the duration of the warm-up protocol, or differences in training environments. Our study reinforces the view that the multi-component nature of the FIFA 11+ program, including exercises like the Nordic hamstring curl and plyometrics, effectively enhances neuromuscular control and physical performance in younger athletes.

In comparison to existing studies, our research on the PEP protocol aligns with findings that demonstrate its limited impact on key performance outcomes, such as sprinting, jumping, and agility [47, 48]. While the PEP protocol has been effective in areas like dynamic balance and injury prevention, its influence on performance metrics remains inconsistent, as seen in previous studies. This contrasts with the more robust effects observed with the FIFA 11+ program, which has shown greater potential in improving physical performance across multiple tests. The relative lack of research on the PEP protocol, especially regarding its impact on athletic performance, suggests a need for further investigation to better understand its role in enhancing sports performance.

Some limitations of this study should be acknowledged. First, the study focused only on the acute effects of the different warm-up methods, without analyzing their chronic impact on performance outcomes. Additionally, the small sample size of participants is a limitation, and future research could benefit from including a larger group. It may also be advisable to conduct studies across multiple teams to increase the generalizability of the findings.

## Conclusions

Some limitations of this study should be acknowledged. First, the research focused solely on the acute effects of different warm-up methods, without evaluating their long-term impact on performance outcomes. Additionally, the relatively small sample size limits the generalizability of the findings. Future studies should aim to include larger, more diverse participant groups and consider conducting research across multiple teams. This would provide a more comprehensive understanding of the effectiveness of these warm-up protocols and improve the applicability of the results for athletes in other sports games.

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