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ORIGINAL ARTICLE

Acute effect of injury-prevention-exercise-based warm-up vs. small-sided-game-based warm-up on speed performance in young amateur soccer players

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ABSTRACT

Purpose: This study aimed to investigate the effects of an Injury-Prevention-Exercise (IPE)-based warm-up and a Small-Sided-Game (SSG)-based warm-up on subsequent speed performance in young soccer players. Method: Twelve male soccer players from the fourth division regional league in Algeria participated in the study. The participants completed both the IPE-based warm-up and the SSG-based warm-up in a counterbalanced order with a one-week interval between conditions. Linear and curved sprint performances, and change of direction (COD) speed, were assessed. Results: The results showed no significant differences between the two warm-up protocols in linear sprint performance (10m and 20m tests) or COD speed (zigzag test) ($p > .05$). However, in curved sprinting, the IPE-based warm-up demonstrated a significant improvement in the 8.5m curve sprint on the right side ($p = .017$, ES = -1.04). No significant differences were observed in the other curved sprint variables (17m on both sides and 8.5m on the left side). Conclusion: the findings suggest that the IPE-based warm-up may enhance speed performance in curved sprints. However, both warm-up protocols had similar effects on linear sprint performance and COD speed. Coaches and Strength and conditioning coaches should consider incorporating neuromuscular exercises in warm-ups to optimize curved sprint performance in young soccer players.
Keywords: Performance analysis, Neuromuscular training, Small sided games, Warm-up, Soccer, Speed performance, Curved sprint.

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INTRODUCTION

Soccer is the most popular sport worldwide, with approximately 270 million participants (FIFA, 2007). It is a high-intensity intermittent sport characterized by the repetition of explosive movements (Di Salvo et al., 2009). Therefore, soccer players require high levels of physical fitness to perform these movements effectively. One crucial aspect of physical fitness for soccer players is speed (Rampinini et al., 2007), which applies to both linear and multidirectional movements (StØlen et al., 2005; Dellal et al., 2010). In recent years, a new type of sprint, known as the curved sprint, has gained attention (Fitzpatrick et al., 2019; Fílter et al., 2020A). Curved sprints differ from cutting movements and linear sprints in terms of biomechanics and neuromuscular activity (Fílter et al., 2020A). Baranovič and Zemková (2021) found that there is no correlation between curve sprint, repeated sprint ability and COD speed in soccer players, and suggested to test and train each quality separately. The curved sprint typically mostly occurs when the radius of the curve ranges from 3.5 meters to 11 meters (Brice et al., 2004). Therefore, many sprints previously considered linear are curved sprints (Fitzpatrick et al., 2019). The curved sprint performance has an important in soccer, especially to create spaces and goal opportunities by midfielders and forwards (Loturco et al., 2020).

Speed performance needs a good training and preparation. A common procedure for preparation for the next event and prevent injuries is the warm-up (Woods et al., 2007). A well-designed warm-up helps improve performance and prepares players for training sessions and matches without causing fatigue (Bishop, 2003). It should take place for a sufficient duration and with appropriate intensity and include exercises relevant to the upcoming activity, whether it is a match or training (aerobic, anaerobic, or technical-tactical).

In terms of warm-up duration, it has been found that muscle temperature increases may occur within the initial 3-5 minutes and reach their peak after 10-20 minutes (Saltin et al., 1968). Van Den Tillaar et al. (2016) discovered that sprint performance improved following both short-duration and long-duration warm-ups. Furthermore, Van Den Tillaar and Von Heimburg (2016) concluded that both a 10-minute short warm-up and a 20-minute long warm-up were effective for repeated sprint ability (RSA) in soccer.

However, in another study, a 25-minute warm-up protocol led to a decline in subsequent performance in 10 and 20-meter speed tests, whereas an 8-minute warm-up protocol was capable of enhancing acceleration ability in soccer players (Javier et al., 2019). This suggests that warm-up should not be excessively prolonged to the extent that it hinders subsequent performance.

Intensity is also considered one of the key factors in constructing the warm-up. The warm-up should be intense enough to contribute to raising the body's temperature, but it should not be so intense that it depletes ATP and CP (adenosine triphosphate and creatine phosphate) stores. According to the findings of Karlsson et al. (1970), the intensity of the warm-up should not exceed 60% of VO2max to avoid exhausting these energy stores. It's important to also take into consideration that the replenishment of ATP and CP stores is rapid, occurring within approximately 5 to 20 minutes (Harris et al., 1976). Consequently, a short time gap between the warm-up and the subsequent event (such as training or competition) of 5 to 10 minutes may be beneficial for the replenishment of ATP and CP stores.

In addition to the duration and intensity of warm-ups, the exercises included in the warm-up routines are of significant importance for enhancing subsequent performance. One of the most important warm-ups aimed at preventing injuries is the neuromuscular warm-up, and FIFA 11+ serves as an example of this. This warm-up includes a series of exercises targeting the lower body, core, and upper body muscles (Herman et al., 2012; Emery et al., 2015). Several studies have demonstrated that warm-ups incorporating injury prevention exercises (IPE) can reduce injury risk factors by approximately 30% (Sadigursky et al., 2017) or 41% (Owoeye et al., 2014) and enhance subsequent performance (Bizzini et al., 2013; Robles-Palazón et al., 2016; Ayala et al., 2017A). This warm-up is designed to improve balance, stability, agility, and power, which are essential for soccer players to perform at their best and avoid injury (Hübscher et al., 2010). It can also be an effective way to enhance long-term performance for soccer players (Ayala et al., 2017B; Akbari et al., 2018; Kessouri, & Dachri, 2021).

Another method that has recently gained popularity in soccer for warming up is the use of small-sided games (Zois et al., 2011). This method is characterized by mentally, physically, and technically preparing players for matches and training through dynamic games with small, medium and large spaces, involving a small number of players. Small-sided games such as 3v3, 4v4, and 5v5 provide a diverse combination of aerobic and anaerobic work (Clemente et al., 2014; Souilah, & Kessouri, 2023). Therefore, they offer an opportunity to elevate the player's body temperature and prepare them for neuromuscular performance (Thapa et al., 2023) as well as enhance their skills (Asgari et al., 2023A). There have been many studies comparing the acute effects of SSG-based warm-ups and traditional warm-ups. Zois et al. (2011) found an improvement in countermovement jump (CMJ) and reactive agility after the SSG-based warm-up compared to the traditional warm-up used by the soccer team. Thapa et al. (2023) also found that the SSG warm-up was superior to the traditional warm-up in CMJ and change of direction speed, while the traditional warm-up showed superiority in sprint performance. Additionally, numerous studies have compared IPE-based warm-ups to traditional warm-ups. Robles-Palazón et al. (2016) found no difference between the FIFA 11+ warm-up and the traditional warm-up in terms of their effects on the physical performance of young soccer players.

However, there is limited research comparing IPE-based warm-up and SSG-based warm-up in terms of subsequent speed performance, particularly among young soccer players. Therefore, this study aims to compare the effects of IPE-based warm-up and SSG-based warm-up on subsequent speed performance in young soccer players.

MATERIAL AND METHODS

Participants

Twelve young amateur soccer players from CRVMJ amateur club active in Constantine regional one league in Algeria (fourth division) who participated in this study, the participants had an average age of 16 ± 0.6 years, a height of 175.16 ± 5.3 cm, and a weight of 60.08 ± 5.96 kg (mean ± SD). It was ensured that all participants were free from any illness or injury and any health conditions. Before their participation, all players, along with their parents and coaches, were provided with a detailed explanation of the experiment's aim, duration, variables, and risk factors. They subsequently provided written informed consent to participate. This study was conducted following the Helsinki Declaration's ethical guidelines (World Medical Association, 2013).

Design and procedures

The present study employed a crossover design to investigate the acute effects of two different warm-up protocols on linear and curved sprints and change of direction (COD) performance in young male soccer players. The study was designed considering previous studies (Robles-Palazón et al., 2016; Asgari et al., 2023A). It was conducted over two weeks, with one week between the two experimental conditions. The first condition involved the use of an IPE-based warm-up, which was designed to enhance neuromuscular control and prepare the players for the subsequent performance. The second condition involved an SSG-based warm-up that was tailored to the specific demands of soccer gameplay.

On the first experimental day, the IPE-based warm-up was performed by all participants. After 03 minutes of the warm-up, linear and curved sprints, and COD speed tests were conducted to assess the participants' performance. After a week, the SSG-based warm-up and previous tests were applied (see Figure 1). The experiments were conducted after four days after the match to ensure a better recovery, and a rest day was given to the players before the two experiments to ensure that the players presented their best physical level.

Both experiments were conducted on Thursdays of each week at 6:45 PM at the same field designated for the team. The temperature was relatively consistent, reaching 18° in the first experiment and 17° in the second experiment. The same testers, including the researcher, coach, and assistant coach of the team, conducted the assessments of the participants. The players wore the same training kit during both experiments, and they were advised to not engage in any physical activity before the experiment and to get sufficient sleep (approximately 8 hours) to avoid any external influences on the experiments.

Data from both experimental conditions were analysed to compare the acute effects of the two warm-up protocols on the participant's performance in the linear and curved sprints, and COD speed tests. The results of this study will contribute to our understanding of the most effective strategies for optimizing the physical preparation of soccer players before training and competitive play.

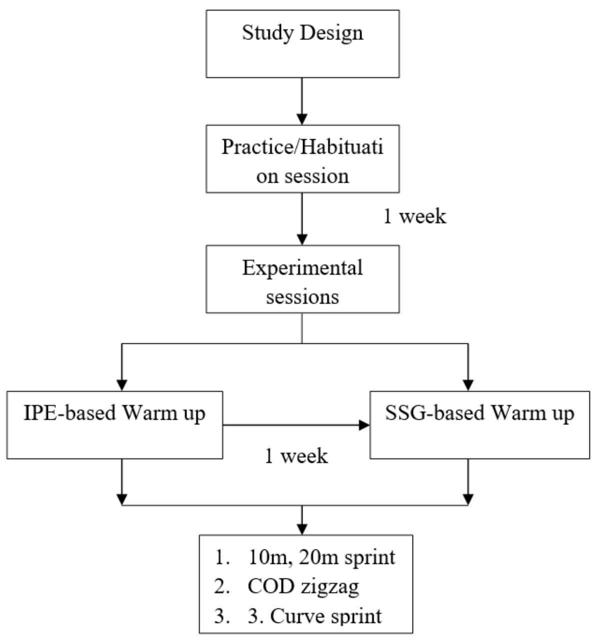

Figure.1 Experimental design.

Warm-up protocols
The IPE-based warm-up protocol begins with a 2-minute jog around the pitch at approximately 60% of the maximal aerobic speed (MAS). Following this, there are 3 minutes of running drills, including high knees, butt kicks, high skips, straight leg runs, carioca, side skips, and ankling. Additionally, there are 2 minutes dedicated to dynamic stretching exercises targeting the hip, adductor, hamstring, calf, and the ankle. The main component of this warm-up entails 10 minutes of prevention exercises, encompassing the plank, single leg bridge, Copenhagen adductor exercise (level 1), Nordic hamstring exercise, and balance and squat exercises. Subsequently, there are 2 minutes allocated to explosive actions, including jumping, acceleration, and change of direction exercises.

The SSG-based warm-up also incorporates a 2-minute jog around the pitch, followed by 3 minutes of running drills and 2 minutes of dynamic stretching exercises. This is followed by 2 minutes of pass/control exercises, leading into a 3v3 game for 10 minutes. For a detailed overview of the main part of each warm-up, please refer to Table 1.

Table 1. The main part of the IPE and SGG warm-ups.

Warm up type	Duration	Exercises	Work		Rest	Series
			Time	Repetitions		
IPE-based warm-up	10 min	Front Plank	30 sec	/	30 sec	02
		Single leg bridge	/	07	30 sec	02
		Copenhagen adductor	/	07	30 sec	02
		Nordic hamstring	/	07	30 sec	02
		Single Leg Balance Reach (04 directions)	30 sec	/	30 sec	02
		Squat	/	10	30 sec	02
SSG-based warm-up	10 min	3v3 (18x25 meters)	02 min	/	02 min	03

Measures

20-m sprint test

The 20-meter sprint test is commonly used to assess linear speed and acceleration in soccer players, and it is an important indicator of explosive power in the lower limbs. The test is conducted on the soccer pitch and involves running 20 meters as fast as possible from a standing start to the finish line; this distance has been divided into two parts of 10 meters to assess the player's speed at 10 and 20 meters. The start line is placed one meter before the starting point, and the finish line is delayed by one meter to ensure maximum player performance. Only the time taken to complete 10 and 20 meters is recorded. A 5-minute rest interval is allowed between two maximal attempts, and the best time is recorded. According to a systematic review by Altmann et al. (2019), this test is valid and reliable for use in soccer.

Zigzag cod speed test

The purpose of the test is to assess a player's change of direction speed over a distance of 20 meters. The player must navigate through cones set up every 5 meters at a 100-degree angle at each turn as illustrated in Figure 2. The test measures key elements of agility, including speed, deceleration, and balance control. The player must rapidly decelerate and accelerate around each cone (Little & Williams, 2005). According to Mirkov et al. (2008) report, this test demonstrates both high reliability (r = 0.84) and high validity (0.98). Each player performed two maximal attempts, with a 5-minute rest in between. The fastest time was recorded for further analysis.

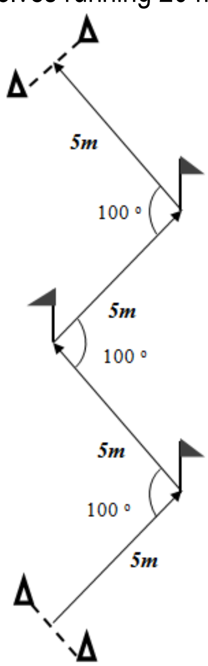

Figure 2. Zigzag COD Test Set-Up.

Curve sprint test

The Curve Sprint Test is a new reliable and valid test suggested by Fílter et al. (2020B). This test involved running along the arc of a regulation soccer field with a radius of 9.15 meters and an angle of 105.84º from the penalty spot. Participants were timed over a 17-meter distance (0-17m) from a standing start, with split times measured at 8.5 meters (0-8.5m) along the curve. The front foot was placed 1 meter before the first timing gate. The players were timed for sides, left and right. The fastest time of three trials for each side was recorded for further analysis. Figure 3 shows how to set up the field for the curve sprint test.

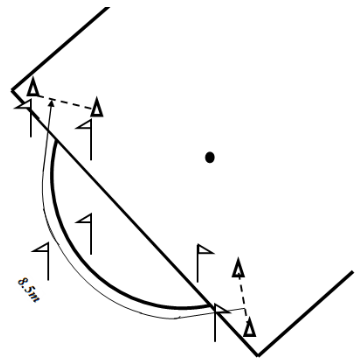

Figure 3. Curve Sprint Test Set-Up.

Analysis
All values in this study are reported as mean ± standard deviation (SD). The data were arranged using Microsoft Excel (Excel 2007, Microsoft, Washington, USA) before being transferred to SPSS (SPSS 26, IBM, Armonk, USA) for statistical analysis. A paired t-test was utilized for within-group comparisons. The significance level was set at $p \leq .05$. Effect size (ES) was used to determine the magnitude of differences between groups. ES values were estimated based on the standardized difference in effect size (ES, 90% CI), and the smallest worthwhile change (SWC), as described by Hopkins et al (2009). ES values were classified as trivial (<0.20), small (0.20–0.59), moderate (0.60–1.19), large (1.20–2.00), or very large (>2.00).

RESULTS

Table 2. The results of the comparison of the effects of the IPE-based warm-up and the SSG-based warm-up on the subsequent speed performance.

Tests		IPE-based warm-up	SSG-based warm-up	Sig	Cohen's d
Linear Sprint test	10m	1.71 ± 0.09	1.67 ± 0.13	.450	0.35 (Small)
	20m	3.07 ± 0.14	3.04 ± 0.25	.775	0.14 (Trivial)
Curve sprint test	8.5m CSRS	1.42 ± 0.06	1.50 ± 0.09	.017*	-1.04 (Moderate)
	17m CSRS	2.66 ± 0.12	2.80 ± 0.19	.055	-0.88 (Moderate)
	8.5m CSLS	1.46 ± 0.08	1.49 ± 0.07	.274	-0.39 (Small)
	17m CRLS	2.69 ± 0.17	2.79 ± 0.17	.161	-0.58 (Small)
Zigzag COD speed test		5.77 ± 0.50	5.76 ± 0.41	.993	0.02 (Trivial)

*Note. CSRS = Curve Sprint Right Side; CSLS = Curve Sprint Left Side, COD = Change of Direction, *p ≤ .05.*

Table 2 and Figure 4 present the results of a comparison of the effects of the IPE-based warm-up and the SSG-based warm-up on the subsequent speed performance.

Regarding linear sprint and COD speed there were no significant differences observed in the 10m test ($p >$ .05; ES = 0.35), 20m test ($p >$ .05; ES = 0.14), and Zigzag test ($p >$ .05; ES = 0.02). This indicates that IPE-based warm-up and SSG-based warm-up had similar effects on linear sprint and COD speed.

For curve sprinting, significant differences were found in the 8.5m CSRS ($p < .05$; ES = -1.04) in favour of the IPE-based warm-up. However, no significant differences were observed in the 17m CSRS ($p > .05$; ES = -0.88), 8.5m CSLS ($p > .05$; ES = -0.39), and 17m CSLS ($p > .05$; ES = -0.58). The effect size shows a moderate difference between IPE-based warm-up and SSG-based warm-up in 17m CSRS in favour of the IPE-based warm-up.

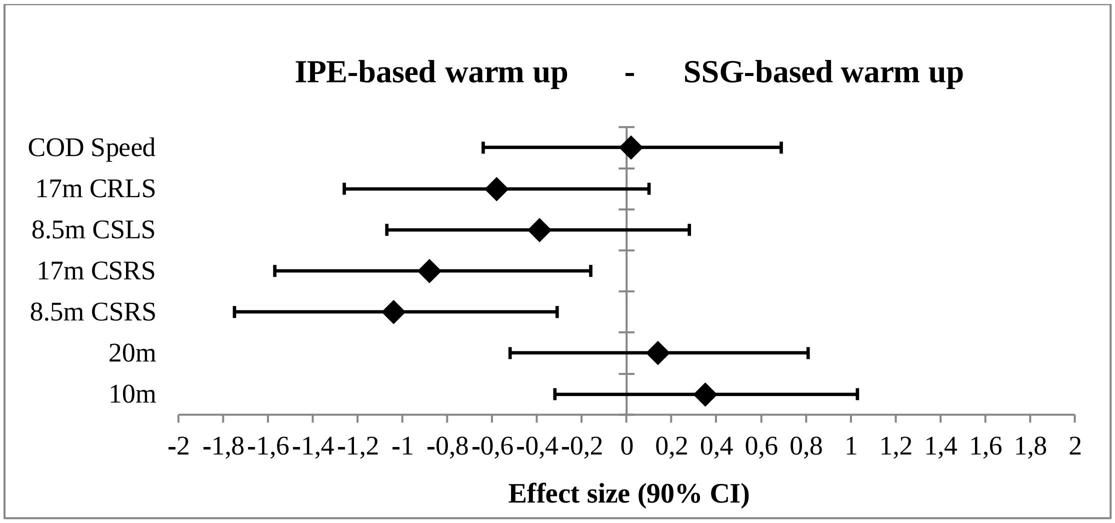

Figure 4. Effect Size for linear and curved sprint and COD speed with IPE-Based and SSG-Based Warm-Ups

DISCUSSION

The purpose of this study was to determine the effects of the IPE-based warm-up and SSG-based warm-up on subsequent speed performance in young soccer players. The main findings of the current study indicated that there were statistically significant differences in favour of the IPE-based warm-up in the 8.5m curve sprint for the right side. Additionally, there was a slight superiority in other variables related to the curved sprint test, specifically the 17m test for the right side (2.66 ± 0.12 vs. 2.80 ± 0.19; ES = -0.88) and the 17m test for the left side (2.69 ± 0.17 vs. 2.79 ± 0.17; ES = -0.58). Although these differences were not statistically significant, the effect sizes indicate a trend toward improved performance following the IPE-based warm-up. The researchers may attribute this remarkable superiority to the fact that the warm-up based on injury prevention exercises contains neuromuscular exercises that target the muscles and joints involved in stabilizing the body (Emery et al., 2015). These exercises have proven effective in improving balance, proprioception, neuromuscular control, and strength (Bizzini et al., 2013; Zekri et al. 2019; Mirzaee et al., 2021), which are among the most important attributes used when performing a curved sprint (Fílter et al., 2020A).

For linear sprint and COD speed, no significant differences were observed in the 10m, 20m, and COD speed tests. These findings possibly confirm that curved sprints have distinct mechanical and neuromuscular properties compared to linear sprints and COD speed (Fílter et al., 2020A). Interestingly, these findings align with the conclusions of another study by Baranovič and Zemková in 2021. Their research also failed to establish a correlation between COD speed and curved sprinting.

The IPE-based warm-up and SSG-based warm-up had a similar impact on linear sprinting and COD speed. Both warm-up methods are likely to enhance muscle action, and motor control, which are essential for optimal performance in linear sprinting and COD speed (Zois et al., 2011; Bizzini et al., 2013; Thapa et al., 2023). Therefore, IPE-based warm-up and SSG-based warm-up are considered suitable warm-up methods. A proper warm-up reduces muscle and joint resistance (Bishop, 2003), enhances the speed and force of muscle contractions (Woods et al., 2007), and improves muscle strength and power (Fradkin et al., 2010). Consequently, both the IPE-based warm-up and SSG-based warm-up produce similar acute effects on linear sprinting and COD speed.

However, these findings differ from those of Asgari et al. (2023A), who demonstrated that football+ warm-up incorporating intensive running exercises, strength, and plyometric exercises, and small-sided games effectively improves acute sprinting, agility, and dribbling in comparison to the FIFA 11+ program. Asgari et al. (2023B) also show through a systematic review that FIFA 11+ as a neuromuscular warm-up has acute negative effects on physical performance compared to dynamic warm-ups and non-significant effects on technical abilities. Carvajal and Salazar (2022) found that warm-up with small-sided games does not enhance COD speed performance. Thapa et al. (2023) also found that the traditional warm-up showed superiority over the SSG warm-up in sprint performance. The difference in these results is due to many considerations such as the duration and intensity of the warm-up, type and number of exercises included in the warm-up, the sample size and the experimental design of the study, as well as the level at which the warm-up was applied, in amateur or professional soccer players.

Therefore, this study has several limitations, it compared the acute effects of two different warm-up protocols, but it did not include a control group. The absence of a control group limits the ability to determine whether the observed effects were solely due to the warm-up protocols or influenced by other factors, such as dietary intake, sleep patterns.

CONCLUSION

In conclusion, this study contributes to the growing body of literature on warm-up protocols for soccer players. The findings suggest that both the IPE-based warm-up and the SSG-based warm-up have similar effects on speed performance in soccer players. The specific advantage of the IPE-based warm-up in curved sprinting warrants further investigation. This study suggests that coaches and strength and conditioning coaches should consider integrating neuromuscular exercises in warm-up routines to optimize performance in sports or activities involving curved movements.

AUTHOR CONTRIBUTIONS

Oussama Kessouri: study design, data collection, data analysis, manuscript preparation. Mohand Ouamer Ait Ouazzou: study design, data analysis.

SUPPORTING AGENCIES

No funding agencies were reported by the authors.

DISCLOSURE STATEMENT

No potential conflict of interest was reported by the authors.

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