Original Article

doi: 10.16926/par.2024.12.01

Comparison of two warm-up protocols for physical and technical-decisional performance in young football players

Rodrigo Villaseca-Vicuña [1ABC], Andrew Gayan-Candia [2ABE], Federico Gazzo [3ABE], Julian Giraldez [4ABE], Santiago Zabaloy [4ABE], Jose Antonio Gonzalez-Jurado [3ABC]

[1] Facultad de Educación, Escuela de Ciencias y Tecnología, Pedagogía en Educación Física, Universidad Católica Silva Henríquez (UCSH), Santiago 8280354, Chile
[2] Facultad de Educación, Universidad de Las Américas (UDLA), Sede Providencia, Manuel Montt 948, Santiago, Chile.
[3] Physical Performance and Sports Research Centre, University of Pablo de Olavide (UPO), 41013 Sevilla, Spain.
[4] Facultad de Actividad Física y Deportes, Universidad de las Flores (UFLO), Buenos Aires 1406, Argentina.

Authors' Contribution: A – Study Design, B – Data Collection, C – Statistical Analysis, D – Manuscript Preparation, E – Funds Collection

Abstract: *Introduction:* Warm-up is a primordial element to optimise sport performance in both training and competitions. The main objective of this study was to compare the acute effect of two warm-up protocols for physical and technical-decisional performance in U16 football players. *Material and Methods:* We applied an integrated warm-up protocol (IWP) of 5 vs 5 in a small space of 20x28 m and an analytical warm-up protocol (AWP) of 12 dynamic exercises that are commonly used in football. Each warm-up was carried out 7 days apart and alternated. After each warm-up, the intensity of the load was recorded through the rate of perceived exertion (RPE), physical performance was recorded using the T30 speed test (time to sprint 30 m) and the kicking speed test, and the Loughborough Soccer Passing Test (LSPT) was applied, which evaluates the football skills of passing and decision making. *Results:* The results show greater technical-decisional performance in LSPT (p = 0.020, ES = 0.55 small) after executing the IWP. However, in T30 (p = 0.129, ES = 0.417 small) and kicking (p = 0.374, ES = -0.29 small), no significant differences were observed. *Conclusion:* IWP presents greater performance in the technical-decisional test of LSPT, and both warm-up protocols have a similar component of intensity and performance in T30 and kicking.

Keywords: integrated, analytical, cognitive, skills

Corresponding autor: Rodrigo Villaseca-Vicuña, email:rvillaseca@ucsh.cl

Recevied: 28.06.2023; Accepted: 10.08.2023; Published online: 3.01.2024

Citation: Villaseca-Vicuña R, Gayan-Candia A, Gazzo F, Giraldez J, Zabaloy S, Gonzalez-Jurado JA. Comparison of two warm-up protocols for physical and technical-decisional performance in young football players. Phys Act Rev 2024; 12(1): 1-12. doi: 10.16926/par.2024.12.01

INTRODUCTION

Football is a team sport with intermittent demands [1]. From the perspective of physical demands, the distances covered in an elite match have been widely studied, reporting distances of 9-14 km [2–4] although the intensity at which such distances are run is not the same in all actions [3] in fact the physical performance can vary between game positions, midfielders are the players with the greatest total distance covered, full-backs are the ones with the greatest number of sprints and attackers are the ones with the highest maximum speed in matches compared to the rest of the positions [5]. From the technical and tactical point of view, it has been reported that the players take a number of 14 shots per game, only 30% were on goal and 7% were goals, 33 dribbles are also made and with an effectiveness of 56% In addition, they manifest a total of 481 passes with an effectiveness of 82% [6]. Regarding the actions that are repeated the most while in possession of the ball and by game position, the central defenders made 8% of the long passes, the full-backs made 12.5% of the centers to the opposite area, the midfielders made 4.3% of the shots on goal from outside the area, the midfielders were the ones who spent the most time in possession of the ball, and the forwards were the players who made the most shots on goal with 4.6% [7].

Within this sport context, warm-up is a usual practice in the preparation of team sports such as football [8,9], and its importance has been demonstrated in different populations, e.g., children [10], young people [11], professionals [12] and female football players [13]. It has been reported that warm-up improves performance and prevents sport injuries, and its aim is to prepare the organism to achieve an optimal state for competition and training [14,15].

Warm-up is usually divided into a general part and a specific part [14]. The general part could be common for any sport or type of physical activity, and it is fundamentally aimed at increasing the body temperature, favouring nerve conduction velocity at the level of the central nervous system and metabolic reactions [16], increasing the blood flow into the active muscles, and increasing oxygen consumption [10]. However, after the general phase, it is recommended that football players carry out a specific part in which they replicate typical movements of the sport gestures that follow the internal logic of football [17], in order to generate a transfer to the next activity, which could be a training session or a competition [16]. In this sense, small size games (SSG) have proven to be an efficient way to stimulate specific physical, technical and tactical aspects in soccer players [9], In fact, a protocol of SSG considering 22.5m^2 per player, improved performance in change of direction and jumping, being SSG more effective compared to a traditional warm-up [18]. In fact, the SSG favor cognitive aspects in soccer, stimulate decision-making on the pitch during the game (reaction speed and decision speed) [19].

The duration of the warm-up session commonly varies between 15 and 40 minutes [12,20], although Zois et al. [9] suggest that warm-up sessions must be short and intense, since longer designs could have a negative effect on the subsequent performance, increasing fatigue prior to the competition and reducing muscle glycogen stores. Therefore, based on the evidence found, there is no consensus in the specialised scientific literature on the types of exercises used and the duration of warm-up in football. In this sense, the parameters considered to evaluate sport performance in football, after executing these warm-up protocols, are frequently physical capacity tests [20,21]. Thus, determining the effects of warm-up on performance in football based exclusively on evaluations of physical skills involves analysing performance in football from a biased or at least limited approach. Consequently, this requires further research to compare the efficacy of different current tendencies of warm-up protocols in football to observe the technical and cognitive performance under competition-like situations. While typical warm-up routines involve constant-intensity exercises, football players increasingly use more activities that simulate the movements and metabolic demands of team sports [9].

Additionally, Lee [22] attributed this potential performance improvement to transfer-appropriate processing (TAP), and Zois et al. [23] stated that the acquisition of specific motor skills in the warm-up can favour the transfer of cognitive processing in similar subsequent tasks.

Therefore, the aim of this study was to compare the acute effect of two warm-up protocols on physical and technical-tactical performance in a sample of U16 football players. Based on the above mentioned, the hypothesis proposed in this study is that an integrated warm-up protocol based on small games of 5 vs 5 in U16 football players will improve the physical and technical-tactical performance to a greater extent compared to an analytical warm-up protocol based on 12 dynamic exercises.

MATERIAL AND METHODS

Participants

Ten U16 football players from a football club of the province of Seville (Spain) completed the study. The participants had the following characteristics (mean ± standard deviation): age (14.4 ± 0.5 years), weight (65.1 ± 11.6 kg), height (1.70 ± 0.05 cm), and experience playing football with a federative license (5.4 ± 1.2 years). All participants were field players (no goal keepers participated in the study), and they trained three times per week (Monday, Wednesday and Thursday) at 8 p.m. for 90 minutes. On weekends (Saturday and Sunday), they played the official competition match. During the study, none of the participants had a history of injury in the 2 months prior to the measurements.

Ethical considerations

All participants were thoroughly informed about the content of the study, its objectives, possible risks and benefits. The tasks and tests conducted in this study were exercises that are usually performed in training (sprints and jumps). All participants had a federative license, through which the parents, at the beginning of the season, signed a document that authorised them to participate in the football activities of the club. This type of intervention neither alters the normal football training nor involves motor actions that differ from those of the usual practice of training sessions and matches; thus, the intervention never posed an additional risk beyond the hazard associated with the habitual football practice. Moreover, all participants underwent a medical examination before the beginning of the season, and the tests were carried out without injuries or physical discomfort. Therefore, this study complies with the requirements of the Declaration of Helsinki [24].

Chronogram

The study was carried out in 8 weeks. The data were collected once per week, every Monday at 8 p.m. (Figure 1). Each warm-up protocol was performed 3 times, 7 days apart, and alternated, in order to avoid interference between designs. During the first two weeks, the players participated in four familiarisation sessions, where they practised the 2 warm-up protocols (integrated and analytical) and the physical and technical-decisional tests. This methodological resource has been previously applied in several studies [23,25,26] with the aim of reducing the influence of learning and the effects caused exclusively by the dynamics of the study protocols.

Design

This is a quantitative, quasi-experimental study with a longitudinal approach (pre-post measures).

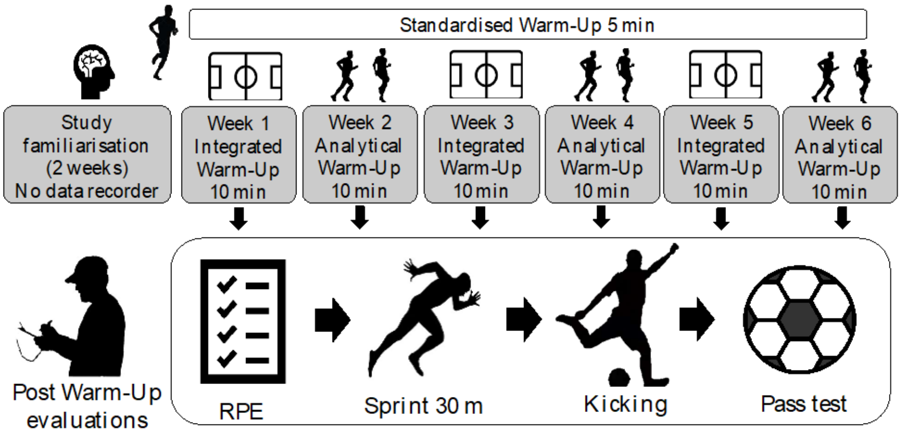

Figure 1. Timeline of the study.

Procedures

The players were asked not to carry out any type of high-intensity exercise on the training day. All warm-up exercises were guided by the physical trainer of the club. The 10 players who participated in each intervention were randomly selected. The rest of the players and goalkeepers conducted habitual training tasks with another technician of the team. Each protocol was initiated with a general 5-minute warm-up of aerobic run at 60% of maximum heart rate [9,27]. After a 3-minute slow-walk recovery, the two warm-up protocols were applied. Next, the rate of perceived exertion (RPE) was recorded, and then the variables of physical and technical-decisional performance were evaluated (Figure 1).

Integrated warm-up (IWP)

This protocol consisted in playing a small game of 5 vs 5 in 20x28 m, with two mini goals of 1x1 m and a ball (Luanvi Nerta, size 5). This task lasted 10 minutes (Figure 2). The game was supervised by the physical trainer of the club, who was also in charge of quickly repositioning another ball in order to maintain the intensity of the game [28]. Once the game began, no verbal stimulation was administered, with the aim of preventing any external influence on the intensity of the execution [29]. The game modification rules were as follows [17]: there were no throw-ins or corner kicks; when the ball left the game zone; the game was resumed from the centre of the field; there were no limits for the number of contacts per player; to consider a goal valid, the entire attacking team had to be in the opponent's half of the field.

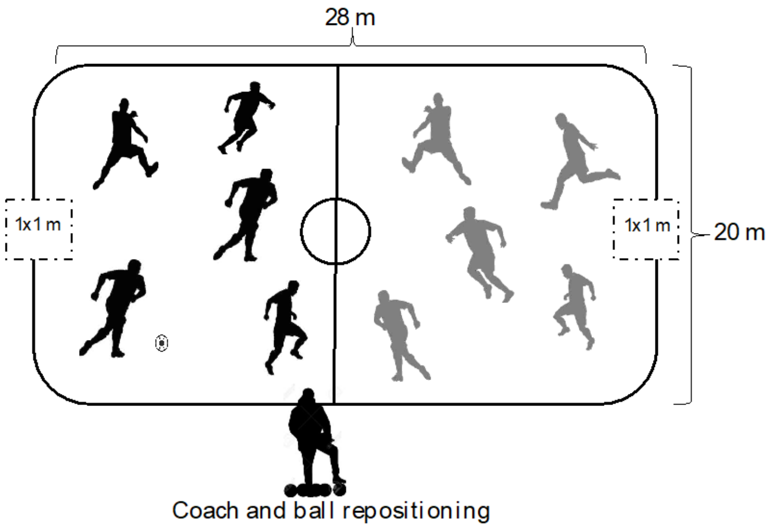

Figure 2. Integrated warm-up.

Table 1. Analytical warm-up description, based on 12 dynamic exercises.

Nº	Exercise	Description
1	High knee skipping	While the player is jogging, raises his knee toward his chest, support is done on the forefoot with alternate arms movement.
2	Dynamic hamstrings swing	While the player is jogging with alternate arms movement, lifts forward one extended leg and then returns to the starting position before repeating with the other leg.
3	Squat and run	The player performs a squat and then runs.
4	Inward hip circumduction	While the player is jogging with alternate arms movement, performs an inward hip circumduction and then returns to the initial position before repeating with the other leg.
5	Outward hip circumduction	While the player is jogging with alternate arms movement, performs an outward hip circumduction and then returns to the initial position before repeating with the other leg.
6	Lateral side to side jog with left leg	The player moves laterally, starting with the left leg, without crossing his feet, his arms remain open to maintain balance.
7	Lateral side to side with right leg	The player moves laterally, starting with the right leg, without crossing his feet, his arms remain open to maintain balance.
8	Lunge walk	The player walks forward performing a lunge, with alternation of the legs, while the trunk remains vertical with arms oscillation.
9	Butt flicks	The player quickly moves the heels toward the gluteus, while the trunk remains straight, with arms oscillation.
10	Backward running	The player performs a reverse running, so that he travels in the direction his back is facing rather than his front.
11	Fast skipping	The player performs a knee raise while advancing. Frequency and range of motion should be considered. The trunk should remain slightly tilted, alternating the arms.
12	Backward running with turn and sprint	The player performs a halfway reverse running, then turns and performs a frontal sprint.

Analytical warm-up (AWP)

This protocol consisted in the execution of 12 dynamic exercises that have been used in other studies for warm-up activities (Table 1), where they proved to be effective in the increase of motor characteristics for sports events in children [10] and young people [17]. Each exercise was repeated 3 times, over a distance of 10 metres; after each execution, the player returned to the starting point on a smooth run, and then conducted the next repetition. This protocol lasted 10 minutes and was guided by the physical trainer of the club, who supervised and corrected the exercises to maintain the body posture and the correct technical execution.

Evaluation tests and instruments

Warm-up loads

To monitor the intensity of the two warm-up protocols, after 3 min of recovery, a rate of perceived exertion (RPE) scale of 0-10 was used, with 10 being maximum exertion. The participants were familiar with the use of this tool. This scale has been used in several studies to observe the intensity of exertion perceived by athletes [28,30]. The coefficient of variation (CV) was calculated to establish the absolute reliability in IWP (CV = 17.5%) and AWP (CV = 23%).

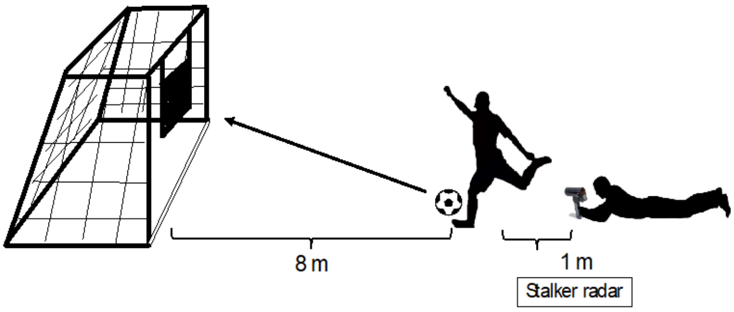

Figure 3. Kicking evaluation.

Time to sprint in 30 metres (T30)

The participants performed three 30-metre runs at maximum speed on the artificial grass of the football field, with a recovery time of 60 seconds. Time was recorded in seconds using a photocell system (Microgate Witty System®). The starting position was 1 m after the first photocell. The mean value of the three repetitions was used for the statistical analysis. The intraclass correlation coefficient (ICC) and the coefficient of variation (CV) were calculated to establish the relative and absolute reliability in IWP (ICC = 0.945; CV 1.30%) and AWP (ICC = 0.953; CV = 1.59%), respectively.

Kicking

The participants performed 3 kicks with the full instep of the dominant leg, with 60 seconds of recovery between kicks. The ball that was used in the warm-up was also employed in the kicking test. The shot was carried out with the ball static and the participant running a distance of approximately 3 metres, aiming the kick at a target of 1 m in diameter that was placed in the centre of the goal, which was 8 metres from the ball (Figure 3). If a mistake in the execution (e.g., not contacting the ball with the full instep) was detected after hitting the ball, the shot was not considered valid, and the player repeated the execution. The ball speed (km/h) was recorded using a radar (Stalker ATS II®) [31], which was placed 1 m behind the kick, following the specific instructions of the radar. The intraclass correlation coefficient (ICC) and the coefficient of variation (CV) were calculated to establish the relative and absolute reliability in IWP (ICC = 0.879; CV 3.33%) and AWP (ICC = 0.913; CV = 3.19%), respectively.

Loughborough Soccer Passing Test (LSPT)

The ball that was used in the warm-up was also employed in this test. A researcher recorded the time with a manual chronometer (DigiSport, modelo DT300), from the beginning of the test until the participant completed 16 passes. A second researcher indicated the colour of the target to which the player had to aim each pass; the colour of the successive targets was indicated to the player right before he completed the previous pass. The order of the colours to which each pass had to be aimed was randomised, thus each test consisted of 8 long passes (green and blue targets) and 8 short passes (white and red targets) for each player. The participants were told that the passes could only be executed from the passing area drawn in the field. It was also explained to them that, after recovering and controlling the ball from the previous pass, the ball had to cross two of the internal lines marked before executing the next pass (Figure 4). Moreover, the players were also instructed that, in order to obtain higher scores in the test, they had to perform it as fast as possible, making as little mistakes as possible, and being as accurate as possible in every pass. A third researcher recorded the time penalties accumulated during the tests. Therefore, three evaluators applied this test: one of them indicated the colour of the target of each pass right before completing the previous pass, another evaluator recorded the time penalties, and the third evaluator measured the time spent and replaced

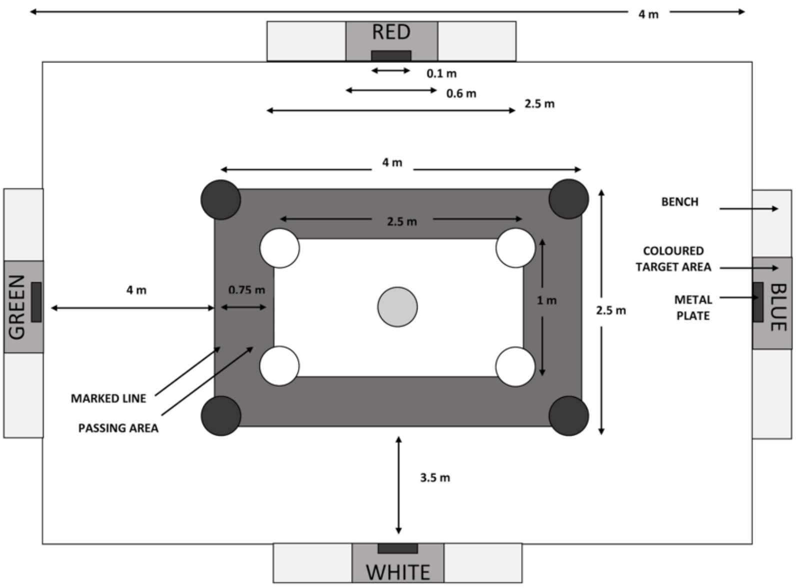

Figure 4. Loughborough Soccer Passing Test (LSPT).

the ball to ensure the continuity of the test. The three evaluators played the same role during all procedures of the test, in order to remove inter-observer variability between evaluations. The players were not informed about the results of the test during the data gathering period. In this test, the outcome parameter was performance time, which was calculated as follows: execution time spent to complete the 16 passes, plus the penalisation time, minus the bonus time. Penalisation time was obtained when missing the target or hitting a different colour (+5 s); hitting the target, but not the coloured target (+3 s); performing a pass from outside of the "passing area" (+2 s); touching any cone with the ball (+2 s); spending longer than 43 seconds to complete the test (+1 s). Bonus time (-1 s) was obtained every time the target was hit. The test was applied and executed following the specifications reported in Ali et al. [32] in football players. The coefficient of variation (CV) was calculated to establish the absolute reliability in IWP (CV = 21.5%) and AWP (CV = 16%).

Statistical analysis

The statistical analysis was carried out using IBM® SPSS Statistics v22. The Shapiro-Wilk test was performed to determine the normality for each variable. To analyse the reliability of the variables, we calculated the intraclass correlation coefficient (ICC), Pearson's coefficient of variation (CV) and the confidence interval (CI) at 95%. To compare the differences between the means of the variables of each protocol, Student's t-test was performed for independent samples, if the variables followed a normal distribution; otherwise, Wilcoxon's test was conducted. The magnitude of the differences was evaluated using Cohen's d effect size (ES) and percentage change (Δ%) [33]. The effects were evaluated according to the following thresholds: < 0.2, trivial; 0.2-0.6, small; 0.6-1.2, moderate; 1.2-2.0, large; > 2.0, very large [33]. The significance level was established at $p \leq 0.05$. For the rest of the analysis, we used SPSS for Microsoft Windows (v24.0, SPSS Inc., Chicago, IL, USA).

RESULTS

Table 2 include the descriptive and comparative data of the study. Differences were only observed in LSPT ($p = 0.020$, ES = 0.55). The rest of the variables (RPE, T30 and kicking) did not present differences between the types of warm-up protocols. Figure 5 include the differences in the passing test between the types of warm-up protocols.

Table 2. Comparison of post-warm-up performance

Variables	Integrated Warm-up		Analytical Warm-up		Differences			
	M ± SD	CI 95%	M ± SD	CI 95%	Δ%	*p* value	ES	Mag
RPE (0-10)	4.40 ± 0.77	4.11-4.68	3.93 ± 0.90	3.59-4.27	-1.25	0.061	-0.648	Moderate
T30 (s)	4.46 ± 0.20	4.38-4.54	4.55 ± 0.25	4.45- 4.64	1.96	0.129	0.417	Small
Kicking (km/h)	100.11 ± 5.62	98.01-102.21	98.57 ± 7.27	95.86-101.29	-1.64	0.374	-0.29	Small
LSPT (s)	54.40 ± 11.71	49.99-58.80	60.96 ± 9.84	57.29-64.64	13.07	0.020	0.55	Small

M ± SD: Mean ± Standard Deviation; CI 95%: Confidence Interval; *p* value: Significance Level; Δ%: Percentage Change; ES: Effect Size; Mag: Magnitude of the differences; RPE: Rate of Perceived Exertion; T30: Time to sprint 30 m; LSPT: Loughborough Soccer Passing Test.

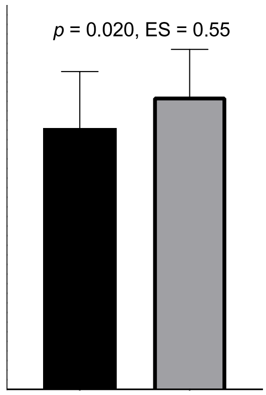

Figure 5. Differences in Loughborough Soccer Passing Test between integrated Warm up and Analytical Warm-up.

DISCUSSION

The main objective of this study was to compare the acute effect of two warm-up protocols on physical and technical-tactical performance in U16 football players.

Regarding the Rate of Perceived Exertion, the results did not show significant differences between IWP and AWP (4.11 vs 3.93, p = 0.061). In the present study, the participants showed similar values of RPE in both protocols, indicating that the level of exertion demanded in the two types of warm-up was equivalent (Table 2). In the study of Castagna et al. [34], small games of 5 vs 5 in 30 x 15 m were performed, and the results of RPE reported were similar (4.1 ± 0.8). These similarities may be due to the fact that the age and competition level of the participants were similar in the mentioned study. However, Rampinini et al. [29] applied small games of 5 against 5 with the same game rules and in an identical space to the one used in our study (that is, 20 x 28 m), and registered a higher RPE (5.9 ± 0.7) . These differences with our results could be due to the fact that the analyzed sample consisted of adult soccer players, who had more experience and a higher competitive level, and, as reported in previous studies, the age and technical level of the players could influence the intensity of the game, in addition, this study considered 3 sets of 4 minutes with a recovery of 3 minutes, this could have influenced the RPE since the volume was divided [28].

Therefore, in the T30 test, no significant differences were found in the means obtained between IWP and AWP (4.4 s vs 4.5 s, p = 0.129, ES = 0.417 small) (Table 2). Similar results have been reported by Gabbett et al. [35] in adolescent basketball players.

The mentioned study compared performance after executing IWP vs AWP, obtaining the following results, respectively: vertical jump (50.9 ± 11.0 vs 50.8 ± 10.3 cm), T5 (1.17 ± 0.06 vs 1.18 ± 0.06 s), T10 (1.95 ± 0.09 vs 1.97 ± 0.10 s), T20 (3.34 ± 0.15 vs 3.36 ± 0.18 s), change of direction (10.47 ± 0.53 vs 10.48 ± 0.61 s) and agility (2.21 ± 0.08 vs 2.20 ± 0.14 s); no significant differences were reported ($p > 0.05$). The results are consistent despite being different sports, but could translate into positive effects on explosive performance in the short term. In team sports such as soccer and basketball that require athletes to run intermittently during the game, it is imperative that warm-ups improve explosive performance [36].These data were also obtained by Coledam et al. [17], who conducted a study similar to ours with children who practised football for leisure, comparing IWP vs AWP, reporting their results as mean, SD and p value, respectively, with no significant differences between agility measures with the ball (14.3 ± 2.1 vs 14.1 ± 1.9 s, $p = 0.24$) and without the ball (11.6 ± 0.7 vs 11.4 ± 0.7 s, $p = 0.75$). These results are in line with those recorded in the present study, where the evaluations of the variables linked to physical characteristics did not show differences of performance between the different warm-up protocols (IWP vs AWP). These findings could be due to the fact that, in our study, both warm-up protocols (IWP and AWP) reported a similar increase of RPE (4.40 and 3.93). In this sense, the increase of RPE could correspond to an increase of body temperature, which is related to physical and sport performance, manifesting with a decrease of muscle stiffness, an increase of nerve conduction velocity, force-velocity relationship enhancement, an increase of anaerobic energy supply, an increase of thermoregulatory tension, a decrease of the effects of lactacidemia, and an increase of oxygen consumption [14,37]. Despite the fact that temperature was not evaluated in our study, two warm-up protocols were applied, whose duration of 15 min (5 min of general warm-up and 10 min of specific warm-up), “somewhat hard” intensity [38] and execution characteristics allow asserting that they easily induced a temperature increase [17]; in fact, it is one of the usual effects of any warm-up protocol [14,37].

With respect to the results obtained in kicking, no significant differences were observed between protocols (100.11 vs 98.5 km/h, $p = 0.371$, ES = -0.29 small) (Table 2). These results are in agreement with those reported by Sáez de Villarreal et al. [39] and Villaseca-Vicuña et al. [40], who demonstrated the benefits of a plyometric training programme in explosive actions such as kicking. These findings showed that a non-specific strength training protocol could favour performance in this type of action for the left and right profile (ES = 0.7 and 0.8, respectively). In this line, Torres-Torrelo et al. [41] found similar results after applying a strength training programme on kicking (ES = 0.5). The mentioned study analysed the effects of a low-load strength programme performed at maximum velocity and its relationship with different measurements of performance in adult indoor football players. Despite the fact that these studies considered intervention programmes and our study analysed the acute effect, a certain relationship could be found, since these findings suggest that rapid stimuli performed by the agonist musculature could determine the extent of strength gain transfer in the shot. Therefore, these conclusions could help to explain the results in this variable, since each method used in our study may have acutely influenced the strength gains. Moreover, kicking the ball could be one of the possible identification tools to evaluate the success of young football players [42].

Lastly, the main finding of this study is related to the results obtained in the technical-decisional measurement through LSPT. In this sense, after applying the IWP, a significantly greater performance was recorded compared to the AWP (54.40 s vs 60.96 s, $p = 0.020$, ES = 0.55 small) (Table 2) (Figure 4). It is worth highlighting that, in this test, the lower the time spent by the participant to complete the passes, the greater the score obtained. These results are similar to those found by Zois et al. [23], who described the effects of two high-intensity and short-duration warm-up protocols on football performance. In this intervention, the players carried out 2 × 26 min of a protocol of intermittent activity on a treadmill, alternating with 15 min of passive recovery; at that time, the two warm-up protocols were conducted: one of them consisted in 3 min of a small 3 vs 3 game, and the other was based on leg extension exercises in a press at an intensity of 5MR (sets of 5 repetitions until failure). The results show that the small-game warm-up protocol improved the performance of passes in LSPT compared to the 5MR warm-up (ES = 0.6), which is in line with the results obtained in the present study. Thus, the warm-up protocol with exercises that resembled the actions of the football game generated the best results. This greater performance in the technical-decisional test LSPT could be explained by transfer-appropriate processing (TAP) [22,23]. This theory explains that trainings through the development of specific motor skills could favour cognitive transfer processing in subsequent tasks [43]; in addition, it has been proved that small games are recommended in populations of young athletes, due to the cognitive benefits that are produced [19]. These findings suggest that situation sports such as football should include periods of specific activity during the warm-up period in order to optimise the execution of subsequent skills [20]. It is worth highlighting that these integrated methods provide different physiological responses, in line with their rules and the dimensions of the game field [9,28,44]. Thus, in football, since it is a team sport, performance depends on certain physical capacities and technical-tactical skills [45-47].

CONCLUSION

In view of the results obtained and discussed in this study, and based on the study hypothesis, it can be asserted that, regarding the most relevant findings, the intensity of both warm-up protocols were similar under the perception of the players, and that, consequently, the IWP through a small 5 vs 5 game generated greater technical-decisional performance measured through LSPT. It can also be concluded that both methods showed similar performance in the physical tests of T30 and kicking.

In practical terms, these data could help the scientific community and sport professionals to introduce integrated warm-up protocols prior to the competition to improve the technical-decisional performance of the players. Moreover, the analytical warm-up protocol could be a good strategy for substitute players to improve their physical performance, since they are not allowed to warm-up with a ball during the game.

The main limitations of the study are associated with the quasi-experimental design (i.e., the use of only one team affects the internal validity related to the trainer) and the lack of a control group in the study design.

Acknowledgments: The authors thank the Castilleja Football Club for providing the conditions to carry out this study.

Conflicts of interest: The author(s) declared no have conflict of interest concerning this work, authorship, and/or publications of this paper.

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