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## RESEARCH ARTICLE

### Characterization of Warm-Up in Soccer: Report from Portuguese Elite Soccer Coaches

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#### Abstract:

#### Background:

Warm-up before competition and training is a strategy that is widely acknowledged to improve players' physical condition and performance. However, the importance of warm-up is not well understood and so there is a research gap into this topic.

#### Objective:

This study aimed to characterize the warm-up of professional soccer players by differences and similarities between different coaches' methodologies.

#### Methods:

A group of thirty-two Portuguese elite soccer coaches participated in this study. An observational study design was conducted through a cross-sectional descriptive questionnaire with nineteen questions. During the questionnaire, coaches were asked to provide specific information about the warm-ups prescribed for soccer players, about their importance from a technical, physical and psychological point of view and the importance they attached to the warm-up / reheating of substitute players. The questionnaire was administered to the coaches at the end of a training session.

#### Results:

The results indicated that there is no consensus regarding the type of warm-up that should be prescribed. There are different opinions between elite coaches regarding the warm-up components that must be emphasized in order to prepare players for the game demands. Moreover, considering the tactical, technical, physical, and psychological dimensions, the coaches have different perspectives of the warm-up.

#### Conclusion:

This study allowed to conclude that there is no standard regarding the prescription of warm-up in professional soccer players, in the opinion of coaches. This is mainly due to the fact that there is a distinct appreciation in relation to the importance and influence of warm-up for performance.

**Keywords:** Players, Exercise, Performance, Body temperature, Muscle, Intensity, Duration.

#### Article History

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## 1. INTRODUCTION

Soccer is a complex and dynamic team sport that requires players to simultaneously combine psychological and physical actions, such as decision making and high-intensity intermittent actions (*i.e.*, sprints and changes of direction) [1 - 4]. To gua-

rantee the players' readiness for these actions and to enhance their neuromuscular performance before training or competition, there is an activity period commonly called warm-up (WU) [5]. It has been a long-held notion that preparation strategies are important [6]. However, only recently, studies presented WU routines as beneficial to performance [6 - 9]. The WU can be characterized as a procedure that prepares the player for specific physical activity, whether in training or competition [10 - 12]. The WU's purpose is to achieve the ideal

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organic and psychological functional state, as well as kinetic and coordinative readiness. Then, it may allow contributing to the injury's prevention [13 - 16]. To improve the player's physical fitness, the WU may increase the muscle and body temperature, passively or actively [9, 17], which significantly influence the players' physiological performance, such as the increase in the volume of ATP production as well as in the increase in the recruitment of muscle fibers I and II [9]. Upon that, the WU can be classified as active or passive, as well as general or specific [13, 18]. Another study, it was revealed that with increases in muscle temperature from 37°C to 41°C improved the performance by 15% [19]. In fact, the WU may increase the body temperature by specific activities in order to improve the player's performance [17, 19, 20]. The active WU consists of low-intensity movements, effective to increase the body temperature, promoting tissue WU, and producing various improvements in soccer players' physiological functions. The passive WU includes the use of external heat paths, such as hot baths, friction, massage, or even diathermy [13].

In soccer, the active WU is the traditionally most known and used WU strategy. However, recently, the passive WU strategies have become more prevalent and have been investigated for their ability to preserve the effects between the end of the WU and the match beginning, and/or the half-time break [6, 9]. Regarding the WU duration, it is possible to find studies with WU time of 5 min [21] and 35 min [22]. The adequate WU should prepare the muscles for physical exertion in competition, causing the least possible fatigue [23]. Moreover, it is claimed that WU minimal duration should be approximately 10 min to reach the greatest possible benefits [14].

The WU intensity is also considered one of the main variables to characterize the exercise and can influence the acute responses induced in response to the stimulus [7, 24, 25]. The intensity is a load component that qualitatively defines the value of the requirement regarding the athlete's maximal capacity [24]. However, the duration and intensity of the WU should vary according to the physical condition of each individual since the time and metabolic reactions necessary to achieve the same increase in muscle temperature are different between subjects [26]. The effort intensity should be lower at the beginning of the WU and gradually increased, thus the muscle temperature may reach a stable value after 10 min [19]. Moreover, the high-intensity WU indicators should consider the differences between the players' field positions and the relationships with explosive physical abilities, allowing to analyze the effect of metabolic power in relation to the player's position [27]. Furthermore, depending on the WU type it may have psychological benefits for players, helping to control anxiety and increase the focus of attention on the game [14].

Despite the importance, the WU exercises are still selected based on empirical knowledge and can be strongly affected by the observation of experienced technical teams routines. Both coaches and players consider that pre-competition WU is essential to achieve good performance [9]. Moreover, they also

agree that the WU planning is as important as any other component of the training/game [14]. However, there is a research gap to support this view. Regarding the WU potential importance to performance, it must be seen as a fundamental part of the preparatory period, before the exercise [28]. Upon that, there is a need to identify and clarify the reasons why coaches adopt different WU routines [19]. In addition, it is important to verify if there is a pattern in the coaches choices of WU exercises and what reasons underlie these choices. To our best knowledge, there are only few studies [29 - 33] that have specifically investigated the perspective of professional coaches regarding the WU typology in different modalities and no study was found in soccer. Therefore, the aim of this study was to describe the WU typology in professional soccer players, asking coaches and assistants of soccer teams from the I and II Liga and National Coaches (NC) by a questionnaire. In addition, we tried to understand if there were differences between the methodological choices used for WU. It was hypothesized that coaches, assistants, and physical trainers had different approaches and perspectives on WU, based on the importance of different structuring factors of WU, and competitive levels.

## 2. MATERIALS AND METHODS

### 2.1. Subjects

During the study period, thirty-two out one hundred and four eligible Portuguese elite soccer coaches participated in this study. Seven coaches and nine assistant and fitness coaches from the Portuguese first professional soccer league in Portugal (I League). Seven coaches and seven assistant and fitness coaches were from the Portuguese second professional soccer league (II League) in Portugal. In addition, one national coach and one national assistant coach participated in the study. In order to participate in the study, coaches had to meet the following inclusion criteria: 1) coaches should have at least 5 years of experience in professional national championships 2) coaches should hold the UEFA Pro coach diploma (4<sup>th</sup> level). All coaches were fully informed, verbally and with a writing consent, about the aim of the study. They were informed that they could leave the study at any time, even after giving their written consent. All participants provided their informed consent for participation in the study, approved by the Academy's Ethics Advisory Committee and conducted in accordance with the Declaration of Helsinki.

### 2.2. Survey Questionnaire

This exploratory and descriptive study was designed to provide comprehensive descriptive information about current WU practices in elite soccer coaches. An observational study design was used with data collected by a cross-sectional descriptive questionnaire with nineteen questions. The questionnaire was applied to the coaches at the end of a training session. All experimental procedures were conducted with coaches' agreement and did not cause any change in the players' training routine (Fig. 1).

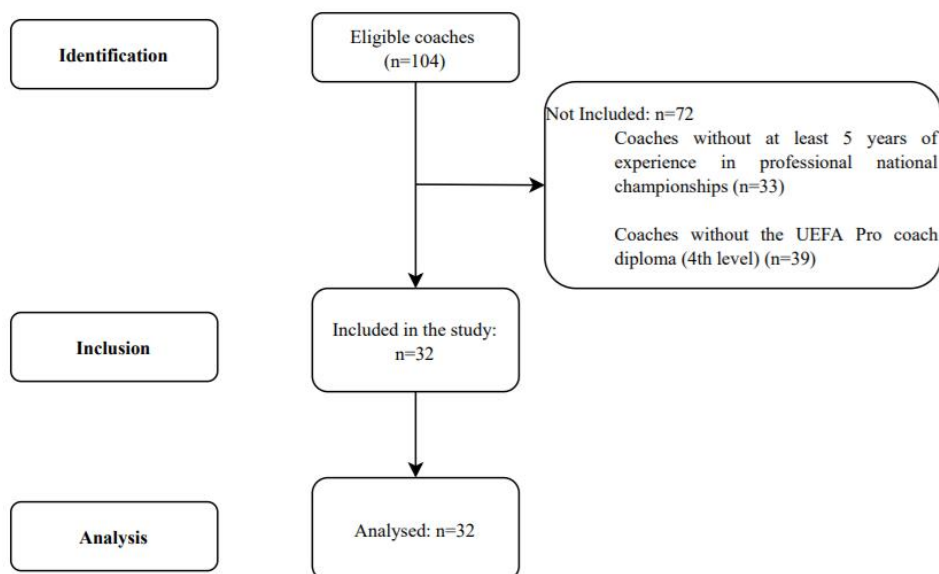


Fig. (1). Study participation flowchart.

The questionnaire was developed by the research team and analyzed by five external experts in the field of sports science (academic researchers and licensed coaches from UEFA). The experts argued that the questionnaire assesses the WU practices used by elite soccer coaches. The theoretical framework used for the design of the questionnaire was based on Mawson [34]. Adjustments were made to make the instrument's statements more clear and relevant to the case. Similar procedures have been used in other studies [35]. Before the beginning of the study, a pilot test questionnaire was completed by five elite soccer coaches to provide facial validity and to guarantee its suitability for this population [30]. The feedback from the pilot test was used to refine the items and the wording to better reflect the current soccer training terminology. However, no data from the pilot study was used as part of this research. Each specialist was asked to establish the adequacy of the questions intending to identify possible inappropriate wording or ambiguities. They rated the degree of agreement regarding the statements in the questionnaire using an 8-point Likert scale from 1 (I totally disagree) to 8 (I totally agree), as previously suggested [35]. In the initial section of the questionnaire, coaches were asked to provide specific information about the prescribed WU for soccer players. These informations were given for training and pre-match conditions, regarding the volume, intensity and recovery, and if the WU type varied according to the weather (*i.e.*, hot or cold). Moreover, the coaches' opinions regarding the importance of WU from a technical, physical, and psychological point of view were studied. The coaches were also asked to discuss the importance that they attributed to the WU/rewarm-up (RWU) of the substitute players before the match the second half start.

Before applying the instrument, the coaches were informed that it was enough to answer questions with a single answer. Even more, the answers may be respected to their own teams' practices, disregarding their ideal WU. In addition, Cronbach's coefficient alpha was used to calculate the internal consistency

coefficients of the items included in the questionnaire [36]. For the overall reliability, the Cronbach's alpha value was 0.75 and the reliability coefficient alpha obtained for each dimension varied between 0.72 and 0.83, indicating the satisfactory level of internal consistency. The questionnaires were administered over two months (April and May) during the 2018/2019 season. Participants had to select a minimum of two and a maximum of seven of the possible answer options [9].

### 2.3. Statistical Analysis

The coaches' responses absolute and relative frequencies were analyzed for each question [23], using the statistical software IBM Statistical Package for Social Sciences (SPSS, version 24.0) for Microsoft Windows (Armonk, NY, EU: IBM Corp.). The *Chi*-square test was used to verify the relationship between the answers and by I or II Liga club coaches, and by role (coach, assistant coach, or strength and conditioning coaches) [23]. Whenever the premises that allowed the use of the chi-square test were not verified (more than 20% of the cells in the contingency table had an expected frequency below 5), the Fisher's Exact Test was used. Due to the characteristics of the sample, a significance  $p \leq 0.10$  was used [37]. To quantify the degree of association between the variables, Cramer's association coefficient  $V$  was calculated. The degree of association was classified on the basis of the following criteria [38]:  $0 < V < 0.1$ : very weak association;  $0.1 \leq V < 0.3$ : weak association;  $0.3 \leq V < 0.5$ : moderate association;  $V \geq 0.5$ : strong association.

## 3. RESULTS

The results described in Table 1 showed that half of the interviewed coaches prefer to warm up for more than 20 min, while the other half prefer a shorter WU (*i.e.*, 15-20 min).

The applied questionnaire showed that most coaches' WU should include specific exercises with and without ball, general activation exercises with and without ball and varied stretches.

It was found that the amount of WU time are higher for the fitness coaches' responses. In addition, it was found that the amount of time is particularly important for the II League coaches and less for the I League and NC coaches. The results showed that the majority of coaches, assistants, and physical coaches believe that the WU main objectives are: the physiological preparation for high-intensity efforts; increasing the capacity to produce strength, the preparation for technical-tactical perspective, and the improvement of muscular endurance and flexibility. The item least valued by the coaches in the WU was mental preparation for the exercise. It was found unanimity among coaches to recognize the importance of WU for injury prevention and improving technical-tactical performance in the matches first minutes.

**Table 1. Relative and absolute frequencies of answers about the duration of the WU before the game, broken down by (i) coaches and fitness coach, (ii) coaches from I League/NC and II League coaches.**

-	Coach		Fitness Coach		I League and NC		II League		Total	
	N	Fr(%)	N	Fr(%)	N	Fr(%)	N	Fr(%)	N	Fr(%)
Minutes										
< 10	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
[10 - 15]	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
[15 - 20]	8	53.3	6	35.3	6	33.3	8	57.1	14	43.8
> 20	7	46.7	11	64.7	12	66.7	6	42.9	18	56.2
<b>Total</b>	<b>15</b>	<b>100.0</b>	<b>17</b>	<b>100.0</b>	<b>18</b>	<b>100.0</b>	<b>14</b>	<b>100.0</b>	<b>32</b>	<b>100.0</b>

Note: Fr=frequency.

Table 2 presents the relative and absolute responses frequencies for the duration of warming for hot and cold

weather. The results showed that coaches consider the importance of climatic conditions to prescribe the WU.

**Table 2. Values of relative and absolute frequencies of the answers for the duration of the WU are equal in both hot and cold weather, broken down by (i) coaches and fitness coaches, (ii) coaches from I League/NC and II League coaches.**

-	Coach		Fitness Coach		I League and NC		II League		Total	
	N	Fr(%)	N	Fr(%)	N	Fr(%)	N	Fr(%)	N	Fr(%)
Yes	2	13.3	2	11.8	1	5.6	3	21.4	4	12.5
No	13	86.7	15	88.2	17	94.4	11	78.6	28	87.5
<b>Total</b>	<b>15</b>	<b>100.0</b>	<b>17</b>	<b>100.0</b>	<b>18</b>	<b>100.0</b>	<b>14</b>	<b>100.0</b>	<b>32</b>	<b>100.0</b>

Note: Fr=frequency.

Table 3 shows the values of the relative and absolute frequencies of the responses if the answer was "NO" about the WU characteristics in a hot climate environment. The table shows a tendency for this response to varying with moderate association depending on the competition level (i.e., League I and League II;  $p < 0.1$ ;  $V = 0.477$ ). Moreover, the same table allows to observe that most coaches prefer a higher WU volume; whereas, a smaller percentage preferred an increased volume and decreased intensity.

Table 4 presents the relative and absolute frequencies for answers about the WU importance regarding the technical perspective. There was a significant percentage of coaches who gave some importance for warming up regarding a technical perspective, while the rest gave a lot of importance or considered that the player's technique is essential.

**Table 3. Relative and absolute frequencies of what characteristics the WU should have in hot weather, broken down by (i) coaches and fitness coaches, (ii) coaches from I League/NC and II League coaches. # 1 - Fisher's exact test.**

-	Coach		Fitness Coach		I League and NC		II League		p-Value (Cramer V)	Total	
	N	Fr(%)	N	Fr(%)	N	Fr(%)	N	Fr(%)		N	Fr(%)
Higher volume and intensity	0	0.0	0	0.0	0	0.0	0	0.0	<b>0.074 (0.477)</b>	0	0.0
Less volume and intensity	6	46.2	4	26.7	8	50.0	2	16.7		10	35.7
Higher volume and less intensity	0	0.0	0	0.0	0	0.0	0	0.0		0	0.0
Less volume and more intensity	5	38.5	10	66.7	7	43.8	8	66.7		15	53.6
Other: Less volume equal to intensity	2	15.4	0	0.0	0	0.0	2	16.7		2	7.1
Other: Less volume	0	0.0	1	6.7	1	6.3	0	0.0		1	3.6
<b>Total</b>	<b>13</b>	<b>100.0</b>	<b>15</b>	<b>100.0</b>	<b>16</b>	<b>100.0</b>	<b>12</b>	<b>100.0</b>		<b>28</b>	<b>100.0</b>

Note: Fr=frequency.

**Table 4. Relative and absolute frequencies of the importance given to WU from a technical perspective, broken down by (i) coaches and fitness coaches, (ii) coaches from I League/NC and coaches from II League.**

-	Coach		Fitness Coach		I League and NC		II League		Total	
	N	Fr(%)	N	Fr(%)	N	Fr(%)	N	Fr(%)	N	Fr(%)
I do not care	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
I give some importance	7	46.7	8	47.1	10	55.6	5	35.7	15	46.9
I give a lot of importance	6	40.0	4	23.5	5	27.8	5	35.7	10	31.3
I consider it essential	2	13.3	5	29.4	3	16.7	4	28.6	7	21.8
<b>Total</b>	<b>15</b>	<b>100.0</b>	<b>17</b>	<b>100.0</b>	<b>18</b>	<b>100.0</b>	<b>14</b>	<b>100.0</b>	<b>32</b>	<b>100.0</b>

Note: Fr=frequency.

Table 5 reports the relative and absolute frequencies of “I give a lot of importance” or “I consider essential” answers by coaches and fitness coaches. The answers vary significantly between coaches, assistant coaches, or fitness coaches with a strong association ( $p < 0.05$ ;  $v = 0.62$ ).

Table 6 shows the relative and absolute frequencies of the coaches' answers on the WU importance from the physical and physiological perspectives. It was found that a large percentage of coaches attributed great importance to WU and considered it essential from the physical/physiological perspective.

Table 7 presents the relative and absolute frequencies of the “I give a lot of importance” or “I consider essential” answers for coaches and fitness coaches. There were differences with a moderate association between coaches or fitness coaches ( $p < 0.1$ ;  $V = 0.459$ ).

Another analysis showed that most coaches believe that the WU has a significant influence on the team's performance in the opening minutes of the match. In addition, 68% consider with some importance to RWU before the start of the second half; whereas only 30% consider it crucial for injury prevention. However, most of the coaches did not give much importance to the WU of substitute players at the beginning of the match.

Regarding the importance of warming up the substitutes before the game, 62.6% of the coaches did not give much importance or gave importance; while 37.5% of the coaches gave great importance and considered it essential. These results come from the fact that 50% of the coaches regard all players

as an integral part of the game plan. However, 25% of the coaches who valued the substitutes' WU before the game stated that their answer was due to the possibility that the players would achieve better performances when they were included in the game. Still, these were only 9.4% of the total sample. In addition, 50% of coaches gave little or no importance to warming up substitute players before the game, as substitutes enter a period of inactivity immediately after the pre-match WU. About 15% of the coaches were justified by the difficulty to make changes at the beginning of the match; and 5% due to the discomfort felt by the players.

The coaches did not give much importance to the WU/RWU of the substitute players before the start of the second half (Table 8). In fact, only a small percentage of the coaches gave a lot of importance to or considered essential the WU/RWU of the players during the break.

Table 9 shows the relative and absolute frequencies of whether coaches answered “I give a lot of importance” or “I consider fundamental” to substitute WU. There was a tendency for the answer to this question with a significant dependency with a strong degree of association by competitive level (*i.e.*, the leagues;  $p < 0.1$ ;  $V = 0.793$ ). The results also showed that 52.4% of the sample gave little or no importance to the RWU of substitute players at the beginning of the second half. The main reason given for this was that the RWU effect would be lost if the player did not enter the game immediately. It was also found that 87.5% of coaches consider this fact as fundamental and place great importance on the WU/RWU of substitutes during the game.

**Table 5. Relative and absolute frequencies of the answers “I give a lot of importance” or “I consider essential” to WU, broken down by (i) coaches and fitness coaches, (ii) I League/NC and II League coaches. # 1 - Fisher's exact test.**

	Coach		Fitness Coach		p-Value (Cramer V)	I League and NC		II League		Total	
	N	Fr(%)	N	Fr(%)		N	Fr(%)	N	Fr(%)	N	Fr(%)
Allows for the preparation and “activation” of the perceptual-kinetic structure	1	12.5	2	22.2	0.043 (0.62)	2	25.0	1	11.1	3	17.7
Allows the preparation and training of specific technical skills	0	0.0	1	11.1		1	12.5	0	0.0	1	5.9
Allows the preparation and adaptation of the perceptual-kinetic structure to the tactical and physical requirements	4	50.0	0	0.0		1	12.5	3	33.3	4	23.5
All	3	37.5	6	66.7		4	50.0	5	55.6	9	52.9
<b>Total</b>	8	100.0	9	100.0		8	100.0	9	100.0	17	100.0

Note: Fr=frequency.

**Table 6. Relative and absolute frequencies of answers about how important it is to warm up from a physical/physiological perspective, broken down by (i) coaches and fitness coaches, (ii) coaches from I League/NC and II League coaches.**

	Coach		Fitness Coach		I League and NC		II League		Total	
	N	Fr(%)	N	Fr(%)	N	Fr(%)	N	Fr(%)	N	Fr(%)
I do not care	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
I give some importance	3	20.0	3	17.6	5	27.8	0	0.0	6	18.8
I give a lot of importance	11	73.3	9	52.9	11	61.1	10	71.4	20	62.5
I consider it essential	1	6.7	5	29.4	2	11.1	4	28.6	6	18.7
<b>Total</b>	15	100.0	17	100.0	18	100.0	14	100.0	32	100.0

Note: Fr=frequency.

**Table 7. Relative and absolute frequency values of whether “I give a lot of importance” or “I consider essential” answer for WU, broken down by (i) coaches and fitness coaches, (ii) coaches from I League/NC and II League coaches. # 1 - Fisher's exact test.**

	Coach		Fitness Coach		p-Value (Cramer V)	I League and NC		II League		Total	
	N	Fr(%)	N	Fr(%)		N	Fr(%)	N	Fr(%)	N	Fr(%)
Allows the preparation of the organic and locomotive structure	1	8.3	0	0.0	<b>0.072 (0.459)</b>	0	0.0	1	6.7	1	3.8
Prevents injuries	0	0.0	1	7.1		1	9.1	0	0.0	1	3.8
Prepares the body for the intensity of the effort of the game	6	50.0	2	14.3		4	36.4	4	26.7	8	30.8
Enhances the ability to generate strength in the early moments of the game	0	0.0	0	0.0		0	0.0	0	0.0	0	0.0
Increases muscle endurance and flexibility for the early game	0	0.0	0	0.0		0	0.0	0	0.0	0	0.0
All	5	41.7	11	78.6		6	54.5	10	66.7	16	61.6
<b>Total</b>	12	100.0	14	100.0		11	45.5	15	100.0	26	100.0

Note: Fr=frequency.

**Table 8. Relative and absolute frequencies of the importance attached to the WU/RWU of substitute players before the start of the second half, broken into (i) coaches and fitness coaches, and (ii) I League/NC and II League coaches.**

	Coach		Fitness Coach		I League and NC		II League		Total	
	N	Fr(%)	N	Fr(%)	N	Fr(%)	N	Fr(%)	N	Fr(%)
I do not care	4	26.7	8	47.1	7	38.9	5	35.7	12	37.5
I give little importance	5	33.3	4	23.5	6	33.3	3	21.4	9	28.1
I give a lot of importance	6	40.0	4	23.5	3	16.7	6	42.9	9	28.1
I consider it essential	0	0.0	1	5.9	2	11.1	0	0.0	2	6.3
<b>Total</b>	15	100.0	17	100.0	18	100.0	14	100.0	32	100.0

Note: Fr=frequency.

**Table 9. Relative and absolute frequencies of the answers “I give a lot of importance” or “I consider fundamental” to substitute WU broken into (i) coaches and fitness coaches, (ii) coaches from I League/NC and II League. # 1 - Fisher's exact test.**

	Coach		Fitness Coach		I League and NC		II League		p-Value #1 (Cramer V)	Total	
	N	Fr(%)	N	Fr(%)	N	Fr(%)	N	Fr(%)		N	Fr(%)
Prevent the appearance of injuries when called to play	0	0.0	0	0.0	0	0.0	0	0.0	<b>0.064 (0.793)</b>	0	0.0
Are part of the game plan	2	33.3	0	0.0	2	50.0	0	0.0		2	18.2
Can be called into play right at the beginning of the 2nd part	2	33.3	1	20.0	1	25.0	2	28.6		3	27.3
All of the above	2	33.3	4	80.0	1	25.0	5	71.4		6	54.5
<b>Total</b>	6	100.0	5	100.0	4	100.0	7	100.0		11	100.0

Note: Fr=frequency.

A total of 53.6% of coaches who considered the WU essential gave great importance to the WU/RWU of substitute players, due to injury prevention. Another important factor is that they can be called up for the match at any time and should be prepared, as stated by 32.1% of coaches. It was also found that 50% of the coaches stated that the main reason for the activity among the substitutes is due to RWU effect will be lost if the player is not called immediately into the game. In addition, the results of this study showed that 87.5% of coaches reported that when substitute players left the bench and went to the WU zone, the most relevant WU structures were light runs, sprints, active and passive stretches, and neuromuscular facilitation.

Finally, it was found that 65.6% of coaches did not use any auxiliary means to optimize WU. Only 28.1% wore a watch

and 3.1% a global positioning system and a heart rate monitor. Also, it was found that 75% of the coaches did not control the intensity of the exercises in any way.

**4. DISCUSSION**

This study aimed to describe the typology of WU in professional soccer with a questionnaire applied to coaches and assistants of soccer teams participants in the I and II League and National Coaches (NC). Methodological differences were found between coaches of different competitive levels, and it was proved that there were different valuations in relation to the components inherent to the structuring / organization of WU, supporting the hypothesis of this study. Some differences were reported regarding the methods used in this study. Differences between WU concerns were also observed in

relation to the championship in which the coaches participated.

Regarding the duration of the WU period in the comparison between coaches from the I and II Leagues, it was found that the majority opted for a WU lasting more than 20 min. These results go against the study of Bangsbo [19], who noted that it should have a duration of 30 min: 15 min to fulfill individual needs in WU, followed by a 10-minute team WU, finished by 5 min where players exercise alone. Towlson *et al.* [30], in a study of English league players, also state that the WU of any team should have a maximum duration of 30 min. It is notable that no professional soccer team considered in this study WUs below the recommended limit. It is also noteworthy that the interval of more than 20 min is more representative for fitness coaches, with a value of 64.7%. However, in a study from van den Tillaar *et al.* [39], the result of a short specific WU is as effective as a long specific WU for sprints in soccer.

Regarding the typology of the exercises applied in the general WU, coaches agreed that it should include: general activation with and without a ball, specific exercises with and without a ball; and stretches. These data contradict the view that the WU is an isolated activity that has the sole purpose of increasing muscle and body temperature [19]. Also, the short specific WU promotes better effectiveness in the soccer player, compared to a general or nonspecific WU [39]. In sports such as soccer or rugby, the application of specific submaximal WU exercises before the game, such as small sided games, interspersed with 4–5 sprint sessions, leads to improvements in player performance [9]. Also, it was found that the use of stretches as part of the WU is a common practice of high use with other WU exercises. Static stretching before general activation or pre-exercise has been used to improve performance and prevent injuries [40]. However, there is much controversy surrounding the application of the different types of stretches, or the non-application, and their benefits for the players. Static stretching aims to bring about a sharp increase in the range of motion in a joint [41]. Research indicates that this type of stretching can also produce a significant sharp decrease of approximately 5 to 30% in the production of strength and in power produced by the elongated muscle group [42]. In support of this, Taylor *et al.* [43] point out that static stretching can inhibit performance in activities that involve the application of force and power in the exercises. These findings have led some researchers to advise against performing stretches before performing strength exercises or power activities [20]. Small *et al.* [44] found that static stretching did not reduce injury incidence rates. The same authors go even further by stating that the effectiveness of static stretching, as part of the pre-exercise WU, remains up for debate and that static stretching may even be considered potentially harmful to performance. Thus, the use of dynamic and ballistic stretches present better results in terms of performance than static stretches. Reinforcing this idea, Frikha *et al.* [45], through a study with young players concerning the accuracy and coordination of shooting in soccer, found that dynamic and ballistic exercises can be recommended before starting activities that require coordination and speed and precision of the lower limbs, compared with static stretches. Still, if the WU training pattern is different from that which characterizes the game, the negative effects could be more evident than those

observed in the WU / training processes under specific [39, 43, 45].

According to the results, only 25% of the coaches focused on the physiological preparation for high-intensity efforts. McGowan *et al.* [9] highlight the fact that raising the muscle temperature passively or actively significantly influences the performance of players through mechanisms, such as increasing the volume of ATP production and increasing the recruitment of type I and II muscle fibers. The physiological dimensions of WU for high physical and mental/psychological intensity activities represented 31.3% of respondents' reasons for favoring WU. Faigenbaum [46] shared this idea, emphasizing the fact that WU prepares the athlete physically and mentally, leading his muscles to the point where work occurs with greater efficiency. In addition, sports WU aims to prevent injuries and enhance the sporting motions performed in each modality [47]. Only 6.3% valued WU for its ability to prepare players mentally / psychologically. However, a previous study suggests that each training session or game should start with a WU and that WU can have psychological benefits [19], which corroborates the findings of an investigation [48] that emphasized the stimulation of the nervous system as being the most important part of warming up.

The coaches reported not having a standardized WU due to the variation in climatic conditions. However, the results show that this answer is directly related to the league to which the coaches belong, with a moderate association between branches ( $p < 0.1$ ;  $V = 0.477$ ). In fact, the coaches considered the ambient temperature when they designed WU. This idea corroborates what was previously reported by Bangsbo [19], who stated that when air temperatures are hot, the temperature of the muscles and body will also increase rapidly, requiring less WU time. However, some WU exercises are necessary to achieve a sufficiently high muscle temperature. In turn, when the weather is cold, players should wear warmer training clothes to decrease the loss of body heat, allowing muscle and body temperature to increase more quickly [19]. In this regard, Achour [49] found that at temperatures of 20 to 30°C, fabric requires approximately three times more tractive force to perform a specific stretch, compared to the force observed at 43°C. The elasticity of connective tissue under moderate stretching increases as the temperature of the tissues is raised to the maximum-tolerated temperature, which is approximately 43°C. Thus, a WU should be used to make the training / game process more effective, avoiding the use of inconsequential tasks of unproven validity and avoiding probable damage to the athletes' performance and integrity. In addition to the climatic conditions, the duration and intensity of the WU should vary according to the physical condition of each individual, since the time and metabolic reactions necessary to achieve the same increase in muscle temperature are different [26].

Another finding of the study was that in cold weather coaches opted for an increase in the volume and intensity of WU, with 10.7% of them opting for an increase in volume but a decrease in intensity in the adverse climatic conditions. However, if the duration and intensity of the WU should vary according to the physical condition of everyone as noted above,

the increase in these two variables should not be linear, but rather inversely proportional. In this regard, a previous study states that the WU intensity that provides maximum oxygen consumption ( $\text{VO}_2$  max) over 60% reduces the concentration of high-energy phosphate. The intensity considered ideal is that in which  $\text{VO}_2$  max is between 40 and 60%, sufficient to achieve an increase in the temperature of the body and muscle nucleus. Hoppe *et al.* [27], meanwhile, note that high-intensity indicators should consider the differences between the positions of the players in the game and their relationship with explosive physical abilities required. Bangsbo [19] also notes that the intensity of the effort must be low at the beginning of the WU and gradually increase so that the muscle temperature reaches a stable value after 10 min. In the final part of the WU before the game, the exercise intensity must be high because the increase in muscle temperature increases the ability of the muscles to produce energy and consequently improves the player's performance.

Another highlight of the study was the fact that coaches attach great importance to warming up from a psychological, mental, and motivational perspective, which goes against what was previously reported [19].

It was found that 68.8% of coaches agreed that the goal of warming up before the game was to physiologically prepare the body for high-intensity effort, increasing the capacity to generate strength, preparing in terms of technical-tactical aspects, and improving muscle endurance and flexibility. Samulski [50] highlighted this application, emphasizing that in any game, any action of a player is the consequence of the interaction of perceptual, procedural, tactical, technical, physical, and psychological capacities, which, in turn, are closely guided by similar previous experiences [51]. Thus, WU for the game and training may consider the athlete's individual characteristics, using technical-tactical actions. That may allow improving the game's reading regarding the individuality of the athlete and the specificity of the team [13].

Another interesting finding was that only a small percentage of coaches considered the RWU at the beginning of the second half as either very important or essential. However, a previous study emphasized the importance of heat retention equipment, given that there were transition periods between the end of the WU and the start of the match, and the interval between the break and restart of the second half that caused decreases in muscular temperature and consequently in the performance of the players [9]. Therefore, it is advisable to RWU before the start of the second half. Active rewarming not only improves the performance capacity of professional soccer players but can also contribute to decisive actions during the second half of the game, as well as to the prevention of injuries during the initial phase of the second half [52].

Finally, a high percentage of the coaches reported they did not use any auxiliary means to control the WU. No study on this topic has been found in the literature, but based on the highlighted importance of this variable, it is recommended that high-level competition teams should use means that monitor and control the players' body temperature during WU tasks.

One of the possible justifications for these results seems to

be related to the fact that there are several heating modalities that can be used as part of the heating process, which goes against what was previously reported in the literature [5]. Furthermore, this study seems to show that coaches from different competitive categories use different strategies to achieve the same purpose, which provides new evidence regarding the topic of study, given that to our best knowledge, no study so far had sought to compare the differences between the WU routines of professional coaches from different competitive categories. We recognize that the present study is a cross-sectional descriptive study and is limited to the opinions of elite soccer coaches. Although the current sample size is relatively small, this was not unexpected, given the challenges in accessing professionals working in top-level sports, coupled with their competitive nature and potential reluctance to share current practice.

## CONCLUSION

The data from this study allow concluding that there are differences in the methodologies used by coaches of different competitive levels. In addition, the assessment is given to the specific components used to build/organize the WU also differs among coaches. The results led to the conclusion that there is no standard interval for the duration of the WU, but it was found that there was great unanimity regarding the types of exercises used, the goals set and the general importance given to the WU before training and games. In fact, the results of the study provide a perspective on the organizational and methodological preferences of WU of a small group of elite soccer coaches, and allow us to conclude that there is no consensus on the methodologies that should be used. Furthermore, considering that the characteristics of the WU can optimize the physical and physiological responses and consequently the performance, this theme takes on special importance and should not be overlooked in soccer, regardless of the players' competitive level. Therefore, the WU routines must be properly planned according to their different components and application contexts.

## ETHICS APPROVAL AND CONSENT TO PARTICIPATE

The project "Characterization of warm-up in soccer: study with Portuguese elite soccer coaches" was approved by the Review Board of the CIDESD-UBI.

## HUMAN AND ANIMAL RIGHTS

No animals were used for studies that are the basis of this research. All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) in compliance with the ethical guidelines of the 1975 Helsinki Declaration as revised in 2013.

## STANDARDS OF REPORTING

STROBE guidelines have been followed in this study.

## CONSENT FOR PUBLICATION

All participants provided their informed consent for



participation in the study.

#### AVAILABILITY OF DATA AND MATERIALS

Not applicable.

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#### CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

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