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INVESTIGATION ON SOCCER REFEREES: A NARRATIVE REVIEW

PAULO CIPRIANO, PAULO MARTINS, RICARDO DUARTE, LUIS PRETO, CÉSAR PEIXOTO, MIGUEL MOREIRA

University of Lisbon, Faculty of Human Kinetics, Department of Sport and Health, Lisbon, Portugal

Mailing address: Paulo Cipriano, University of Lisbon, Faculty of Human Kinetics, Department of Sport and Health, Estrada da Costa, 1499-002 Cruz Quebrada-Dafundo, tel.: +351 214 149175, e-mail: bdjz2012@gmail.com

Abstract

Introduction. The heightened physical exertion stemming from greater physical loads in football matches has elicited greater development of physical conditioning in both players and referees. ***Material and methods.*** The current study consisted of a meta-analysis geared towards identifying the scientific data currently available on the training of referees. ***Results.*** With respect to the characterization of the training of football referees, the results of this study showed that there is a diversity of both its methods and contents. As a result of this and based on the support offered by the meta-analysis, a proposal for categorizing the contents of this training is presented. Testing-wise, the results also showed that the FIFA test fails to identify the varying intensities that occur within a match setting and to characterize the distribution of referees' varying exertions throughout match settings. Lastly, the results of this study also indicated that the training of referees ought to include periodization guidelines over the course of a season, since doing so allows for the optimization and monitoring of referees' performance.

Key words: refereeing, tests, performance, physical conditioning

Introduction

Football is one of the most popular sports in modern societies [1]. In the case of both football and other team sports, different roles are played out by the players, coaches and referees. The latter have the unique responsibility of supervising how players implement the rules that govern the game at play, thus ensuring that players abide by them [2]. The role of the referee in organized sports is so important that in their absence, the game cannot take place [3].

In the specific case of football, referees are assisted by two or more assisting referees, depending on the competitive context [4]. Football referees are permanently in motion, as they are free to move anywhere on the pitch in order to find the best possible place for processing the events of the match. Finally, football referees cannot be replaced, barring the exceptional case of injury [5, 4].

Refereeing is a multi-dimensional activity, as it includes different forms and levels of analysis [4]. Amongst them are included technical, biomechanical, tactical, mental and physiological elements [4], as well as cognitive, anthropometric and psychological components. The sum of the latter allows for the performance of tasks specific to refereeing, which are at the centre of how a sport and its rule set interact [6]. Though the referee is the one responsible for ensuring the application of the rule set that governs each sport, research into the role and performance of referees is both quite recent [7] and limited [5].

Over the past fifteen years, very little scientific literature has been produced on the performance of football referees, which means that analyses of performance traits and performance indicators of referees are scarce. This is, at best, unfortunate, as indicators of refereeing match performance are crucial in providing robust measures that allow for an effective assessment of referees' performances. The few studies conducted during the aforementioned period indicate that there is a diversity of methods and contents that characterize the training of football referees.

In light of the above, a breakthrough meta-analysis study on the evolution of the research literature in the context of refereeing was deemed relevant. In pursuing such a study, a proposal was generated for categorizing the contents that were gathered. Such a step facilitates the analysis of the topics already studied, while also enabling the diagnosis of issues that future research efforts should focus on.

Therefore, the research analysis of refereeing needed to focus on what makes up refereeing and what contributes to the performance of referees.

In systematizing and summarizing the scientific information on the role of referees, we sought to improve the consistency of this ever growing, but still insufficient, refereeing-centred research field, so as to facilitate the redefinition of both the perspectives held on this subject and the focus points of future research.

It should be noted that an important advantage of meta-analysis is that it allows for studies to be selected based on constant and reliable criteria defined by researchers. This improves the homogeneity of the selection process and, as a result, the subsequent interpretation process is made simpler and more meaningful [8]. In short, it is possible to establish a set of objective criteria that ensure objectivity during a later review stage. These criteria are, obviously, strongly dependent on the hypotheses that are formulated, themselves an outcome of each specific research field [9].

For the current analysis, we chose to investigate what makes up the activity of referees as well as what contributes to its effective outcome. Ultimately, given the lack of systematic reviews available on this subject, we searched for references in studies concerning the characterization of the performance of football referees, football refereeing and the process of decision making, morphological and physical traits of referees, as well as training

of football referees and physical conditioning tests used in the specific context of football referees.

Material and methods

Search strategy and study selection

The systematic analysis of the literature was conducted according to the database gathered using online search engines, including both national and international journals in Portuguese, English and Spanish. As established by Petticrew and Roberts [10], the selection of articles was conducted based on the criterion of the usage of the following terms: soccer, referee, football referee, soccer refereeing and refereeing performance. Such terms were researched both in English and in their corresponding Portuguese and Spanish translations, in articles that use these terms within their keywords, titles and abstracts.

For this purpose, we resorted to the online databases Science Direct, Pubmed, Sportdiscus and PsycINFO, while limiting our research to the context of the football referee within research fields connected to sport activity and physical conditioning.

Eligibility criteria

The quoted articles needed to fulfil several eligibility criteria (Tab. 1). They were to be empirical articles published in journals with peer review between January 2000 and June 2017 which mentioned the characterization of the referee's activity while specifying the importance of the referee's physiological profile. Furthermore, the individuals making up the sample needed to be currently active males, and the articles could not mention conflicts of interests.

The following types of sources were excluded: non-empirical articles, theoretical essays, masters and doctoral theses, book chapters and sport newspapers, records of congresses that were published in journals with peer review that have also been published as articles in other journals and articles that fall outside of the above-mentioned timeline.

Table 1. Eligibility and exclusion criteria applied in the process of selecting research studies for systematic analysis

Eligibility criteria	Exclusion criteria
Reporting only on male subjects.	Records of congresses published in journals with peer review also published as articles in other journals.
Articles that mention the characterization of the referee's activity, while specifying the importance of the referee's physiological profile.	Non-empirical articles, theoretical essays, masters and doctoral theses, book chapters and sport newspapers.
Empirical articles published in journals with peer review between January 2000 and June 2017.	Articles published either before January 2000 or after June 2017.

Data extraction

Given the variety of topics and constructs present in the articles, different approaches were used in order to better understand the variables, methods and statistical procedures selected for each study. Therefore, the analysis used in this study is a narrative one, involving the systematic extraction, verification and summary of methods and results that allow for an overview of the studies [10].

A total of 671 articles were gathered, of which 178 were preselected. In the end, 135 articles fulfilled the eligibility criteria determined for this study. After going over each abstract, all articles included in this study were acquired in their full version and re-evaluated according to the previously determined eligibility/exclusion criteria, thus allowing for the confirmation of the eligibility criteria pertaining to either inclusion or exclusion.

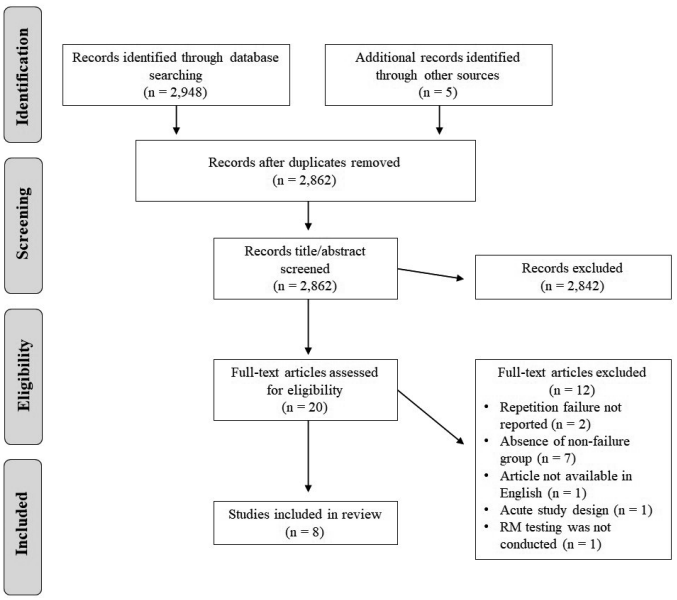

Figure 1. Overview of the studies after extraction and verification of the results

Quality analysis

An initial analysis was conducted based on the titles of the articles. Afterwards, we proceeded to reading the articles whenever the research terms were absent from the title and abstracts.

Our investigation was based on the verification of the eligibility criteria, together with the reading of all the articles. In doing so, our purpose was centred on reviewing, in a systematic manner, their content, so as to extract the information deemed relevant.

Afterwards, through a deeper and more detailed reading, the central characteristics of each article were recorded. More specifically, we looked to identify and summarize the goals of each study, the participants, the evaluation tools for analysing the performance of referees, the traits of the tasks and, finally, the main conclusions presented in each article concerning the topic at hand.

Later, given the lack of consensus amongst the theoretical models for classifying content analysis in football refereeing, it was decided that a mixed model, based on several authors, would be implemented. This model derived from the model proposed by Mascarenhas et al. [11], Stolen et al. [4], Guillén and Feltz [12], Weston et al. [13] and Slack et al. [14]. We then proceeded by integrating the results of different studies, with the intention of extracting reference data meant to be used both in this study and future ones.

Results

Description of studies

The data were organized by publishing year, number of articles per year and their respective percentages. In doing so, we looked to establish a more precise notion of not only the quantity of the articles but also the relative impact that each year had on the research of football refereeing. A table was created according to the method-centred information, resulting in the

Table 2. Categorization of articles by publishing year

Categories	Total	Sub-Categories	Sub-Total	Year																	
				2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Morphological and physiological traits of refereeing	76	Anthropometry and somatotype	23						1			3		1	2	4	1	2	1	4	4
		Physiological traits of activity	31		3	1	1	1		2	5	3	4	3	4	2	2				
		Age	4						1		1	1		1							
		Physiological parameters of referee	18				1		1	1	1	2		1	3	1		2	2	1	2
Non-physiological factors influencing refereeing	50	Hydration	3				1								1			1			
		Injuries	7									1	1		3		2				
		Nutrition	4							1								1	2		
		Perception and cognition	5					1							2			3			
		Psychology	17					1		1		2	1	4	3		2	2	1		
		Decision making	14			1				1		1	2		2	2	2	3			
Training and evaluation tests of referees	26	Training	12					1	1		2		1		3		1	2		1	
		Evaluation tests	14			1	1		1		1	1	3		1	2	1		1	1	
Total	152	Total by year		0	3	1	4	5	5	6	10	14	12	10	24	11	11	16	7	7	6

distribution of the articles over 3 categories, 12 sub-categories and publishing year (Tab. 2).

Though other options would have been acceptable in defining and categorizing the contents of the scientific articles that were selected, given the broad consensus concerning this topic, we decided to opt for this particular approach.

These data show an overall rise in research concerning the traits and characteristics of football referees from 2007 onwards.

As already mentioned, 135 articles were considered to fulfil the eligibility criteria. The category "Morphological and physiological traits of refereeing" had the highest total of research studies, 62 articles, which corresponds to 45.93% of all the studies analysed in the current study. The second largest category, with 49 articles, is that of "Non-physiological factors influencing refereeing" and corresponds to 36.30% of all studies. Lastly, the category "Training and testing of referees" is made up by 24 articles, corresponding to 17.77% of all the studies analysed.

From 2007, the number of published studies on this topic rose, as indicated by 24 articles published in 2011 and 16 in 2014. These numbers represent a stark contrast to 24 peer-reviewed articles published in scientific journals between 2001 and 2006.

On five occasions (2001, 2006, 2007, 2009, 2011 and 2012), the category "Physiological traits of the activity" had the highest annual output of publications, while 2010 saw the category "Decision making" recording the highest number of published articles. Lastly, in 2012, it was the category "Anthropometry and somatotype" that took centre stage.

It should be noted that the articles within each category were not homogeneously distributed over the years, which is easily noticeable through the mere 22 articles produced on the topics of "Hydration", "Nutrition", "Age", "Perception and cognition" and "Injuries".

We found a great difference between categories, with the categories "Morphological and physiological traits of refereeing", "Non-physiological factors influencing refereeing" and "Training and testing of referees" registering 62, 49 and 24 articles, respectively.

From all the articles mentioned in the category "Morphological traits of refereeing", 31 of them pertain to the subcategory "Physiological traits of the activity", 14 to "Anthropometry and somatotype", 13 to "Physiological parameters of referees" and just 4 to "Age".

The category "Non-physiological factors influencing refereeing" contains 49 articles considered to fulfil the eligibility criteria. Of these, the articles on "Psychology" make up the largest sub-category, with 17 articles. Second to it, the subcategory "Decision making" totalled 14 articles, which may be a result of how the specific contents of this research topic interact with one another, having a similar distribution over the timeframe in question.

The categories "Hydration" and "Nutrition" stand out from other categories since each one totalled only 3 articles, which we consider to be very low totals given the impact that these parameters can have on the performance of referees.

The 24 articles that make up the category "Training and testing of referees" are split into two sub-categories: "Training", with 11 articles, and "Evaluation test", with 13 articles. Though these numbers are not that different, their publication over the 2001-2004 period was not homogeneous.

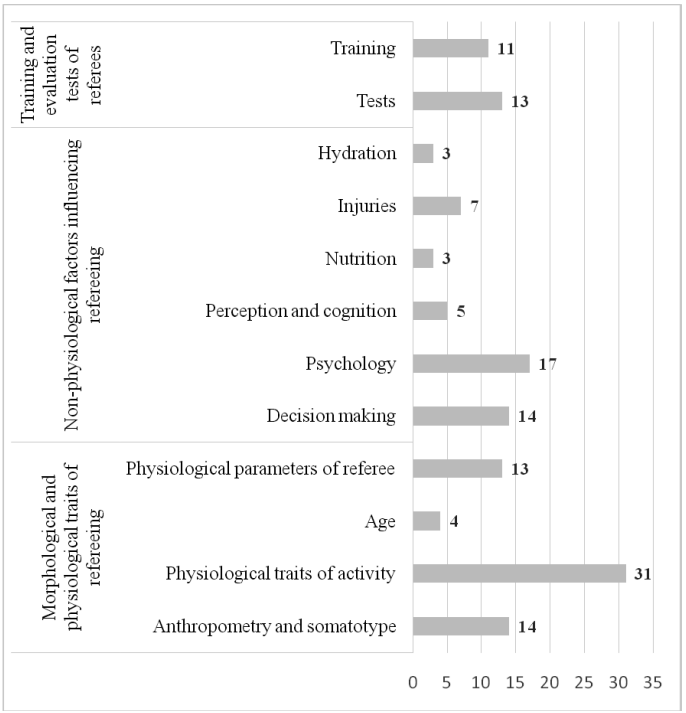

Figure 2. Distribution of articles by category and sub-category

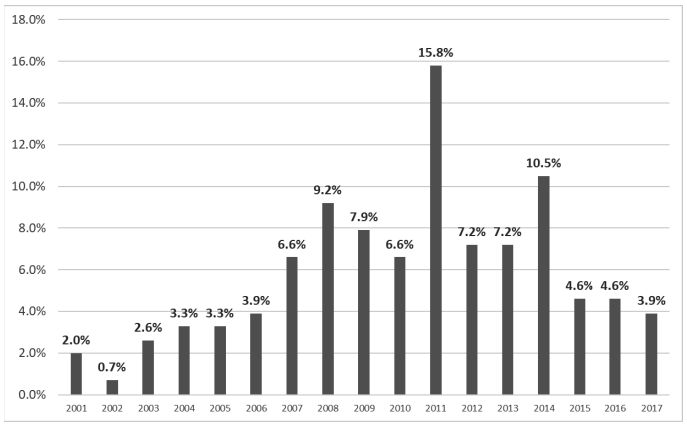

Figure 3. Studies published from 2007 to 2011

The sub-category having the highest representation, with 31 articles, was that of "Physiological characteristics of the activity", while the sub-categories of "Nutrition", "Hydration" and "Age" recorded the lowest output of articles with 3, 3 and 4 articles, respectively.

Additionally, the latter sub-categories also had their publications more greatly dispersed over time, thus failing to follow the pattern of regular publishing identified in the other sub-categories.

Also relevant are the seven articles that constitute the only source on the topic of "Injuries". Figure 2 shows the distribution of the published studies, including both their particular concentration from 2007 to 2011 and the very limited output during the first years of our timeline.

In another analysis, which includes the number of articles published by year and the corresponding percentage of the total number of publications, we were able to establish a better notion of how much each year contributed to the publishing timeline in question (Tab. 3).

The year 2011 saw the release of 17.78% of all the scientific articles that were published between 2000 and 2015. In stark contrast to this, both 2001 and 2015 contributed just 2.22% of all studies published, though the latter year was only analysed until June 2017. Percentage-wise, the years 2007, 2009, 2010, 2012 and 2013 were similar, with percentages that ranged from 7.41% to 8.15%. There is, between 2007 and 2014, some balance as to publications by category, though the category "Morphological and physiological traits of refereeing" does show a slight edge, as previously stated.

Discussion

Non-physiological factors influencing refereeing

Refereeing is, currently, one of the most polemic elements of sport. This is never more obvious then when its several intervening actors refer, at one time or another, to refereeing as having great influence on competitive results [15].

In their endeavour to manage football matches impartially, referees are confronted with the need to reach quick decisions while failing to be fully sure of all the factors that come into play and, occasionally, even being confronted with ambiguous scenarios [16]. The performance of a referee is judged based on their ability to manage the match, physical conditioning and decision-making skills [17]. Nevertheless, referees' decision-making skills are the element which is the most widely exposed and, hence, most discussed among the several elements that make up sport settings. Consequently, referees' decision-making skills end up being a major factor in determining how positively or negatively a referee's performance is viewed by others [17]. When it comes to analysing a referee's performance in terms of match management skills, perceptual-cognitive skills and psychological skills, it needs to be considered that these are influenced not only by each other but also by injuries, hydration and nutrition. There is, indeed, a connection between these elements, since episodes of mismanaged decision making can result in stressful scenarios that are influenced by elements of a social, psychological and biological nature [15]. For example, in a study that included 116 Turkish referees, Gencay [18] determined that the average stress level of his sample varied between "low" and "moderate" over the course of a season. These results match the results obtained in other studies, confirming the low level of stress that referees are under while refereeing [19, 20].

This can be attributed to the fact that more experienced referees taking part in high-level competitions are more successful in managing stress, the cohesiveness of the refereeing team and the importance attributed to the way onlookers evaluate their performance [19]. Despite this, referees managing matches that are both more challenging and of a higher competitive level can exhibit higher anxiety levels than their colleagues refereeing at lower competitive levels. Overall, referees' anxiety level is greater amongst those who perceive their performance as either mediocre or average, when compared to those who perceive it as good [20]. On the other hand, stress values seem to be different when analysed under varying socio-cultural contexts. For example, the stress levels of Brazilian referees are different from those found amongst Turkish referees [19, 20]. Moreover, we found data that points to social pressure having a meaningful influence on experienced and inexperienced referees. This, in turn, generates the question whether more experienced referees are able to manage social pressure better [21]. For these reasons, we can consider that there is a tri-dimension that includes biological,

social and psychological elements that contribute to the development of stress amongst referees before and after matches [15]. Additionally, by getting to know the process of decision making, we may be able to infer with greater accuracy which elements precede and which ones follow the performance of referees.

On the other hand, the decisions made in sports, including football, are of a "natural" nature. The reason is that they are made by persons who are familiarized with actions specific for the setting in question and, furthermore, within a context where the decision-making process is meaningful [22]. The latter translates to decisions within a game setting being viewed by some as tasks of a perception-action type. Doing so requires, in a dichotomous manner, that referees pass judgement of a violation/non-violation type [23], while facing a dynamic and highly uncertain environment that includes opposing goals, time pressure and relating with multiple players under constraining organizational factors [24]. Adding to this, a large number of decision-making procedures applied by referees have to do with violations and undesirable behaviours [23]. Therefore, referees' decisions play a crucial role in the quality and development of the sport itself [25].

Given the above, we are able to establish a set of approaches to analysing refereeing that generate a number of factors influencing decision-making skills and, thus, the referee's performance. The latter include: the number of decisions made during a match (between 3 and 4 per minute), the teams' reputation for aggressive behaviour, environmental noise, the referee's anxiety and experience, the effect of previous decisions concerning violations, the arrogance of players who commit violations, differences specific for performing under pressure, and media-related social and national pressure [22]. It is interesting to note that the body language of players has no relevance and fails to impact the referee's decision on whether to sanction a violatiStudies centred on referees' decision making within real match settings showed that it is impossible to distinguish between behaviours meant to implement the rules of the sport and those meant to control and manage the match. The whole process of decision making is, according to a naturalistic perspective, an activity of constant interaction [22]. This reinforces the notion of there being multiple factors influencing the process of decision making. Regarding the relationship between physical conditioning and decision making, referees' displacement speed is deemed to influence their refereeing precision [5, 27, 28]. Nevertheless, other studies did not confirm this relationship. According to the authors, such differences may occur due to differences in competitive level between the matches that were analysed. Simply put, these studies included both youth and professional matches, but with the first lasting only 20 minutes per half and the second more than twice as long (45 minutes per half, thus totalling 90 minutes).

Additionally, no connection was found between heart-rate and distance covered. Therefore, none of these variables can be looked at individually in order to explain decision making within a holistic model of the referee's activity. One needs to, instead, rely on a set of multi-variables in defining the relationship between physical conditioning and decision making in the activity of referees [11].

Morphological and physiological traits of refereeing

As regards physical conditioning, the activity of referees entails dealing with highly demanding physical loads [29], making resistance to fatigue of utmost importance. Mrkovic et al. [25] argued that a high resistance to fatigue allows for easier and more consistent decision making. Considering the several types of physical demands that a football match imposes on referees, research has been working towards describing a profile that takes into account the performance and physiological variables that make up this setting. For example, referees cover between 9 and 13 km [27, 5], with heart-rate values that fall between 85 and 90% of their maximum heart rate and an oxygen intake that ranges from 70 to 80% of their maximum (VO_{2max}). Additionally, Castagna et al. [30] showed that the age of referees does not interfere with their ability to keep up with the activity of the match. A practical example of this is that of referees being, occasionally, almost double the age of the players (15 to 20 years older) and still capable of changing motor action every 4 seconds (totalling 1,268 different actions per match). This means that it is important to take into account the technical elements of performance, physical conditioning and the physical profile of a match setting, and not merely age, upon establishing the upper limit for a career in refereeing [31].

During matches, referees engage in low-to-moderate physiological outputs. Therefore, though referees also generate high-energy anaerobic outputs, they mostly mobilize the aerobic energy system. Refereeing is, however, is considered to be a mixed aerobic-anaerobic type of effort [32].

The required performance level and degree of effort that matches place on players directly affect the effort demanded of referees as well as their actions. Research has progressively shown that there is a positive association between the intensity of elite players' tasks and the degree of effort exhibited by referees [5]. Such data has been found amongst referees and players that take part in the whole match, but not when analysing replacement players [33].

Therefore, for Weston et al. [13], the physical output of referees is directly associated with that of players. Though we can still find differences over the course of different football matches, one of the factors that determine the intensity of the actions of referees is the intensity of each match. The latter is measured by the total number of high-intensity actions and the displacement speed of the players. Such data is used to quantify the total distance covered over the course of a season, together with the percentage that was covered sprinting [33, 34].

This information is deemed particularly relevant, given that there is strong evidence that the total distance covered by referees is close to that of midfielders [4]. Such similarity in distance covered by these two groups probably occurs because midfielders act as a link between the defensive and the offensive sectors. This has midfield players moving in the same line of action as that of the referees, who need to move in such a manner as to effectively keep up with match play [5].

Nevertheless, the total distance covered by referees cannot be used in determining their fatigue level, since 75% of their actions take place while performing slow jogging or not moving at all [35].

Though referees do not exhibit maximum oxygen consumption (VO_{2max}) levels similar to those of players, their levels still affect refereeing performance, particularly in the context of their relationship with total distance covered and high-intensity displacements [4].

Based on the assumption that total energy production during a match is directly connected to the total amount of work performed, total distance covered during a match constitutes an overall reference for heart-rate output, while total distance covered by means of high-intensity displacements is positively connected with the aerobic capacity of referees [32].

One should also include in this analysis backward displacements, in which VO_{2max} and heart-rate are 15% higher when

compared to forward displacements. Though not performed at sprint-level intensity, the action of moving backwards is more demanding (due to its intensity level in terms of both the metabolic reaction and the cardio-respiratory reaction) and, therefore, requires a greater energy output than that of forward displacement [32].

In the several studies that we mentioned concerning this topic, the authors did not reach a consensus regarding the categorization of displacements, speed values or distance covered within each category. In light of this, we opted for the definitions established by Di Salvo et al. [36], which are based on the analyses of the champions league, the European championship and the English league, in establishing the values and categories that define the displacements of football referees (Tab. 3). It needs to be noted, however, that this table makes no reference to backward displacements, which we consider to be a clear limitation since, as already stated, these displacements actually elicit a greater metabolic output [32].

Table 3. Categorization of the displacements of referees according to speed [36]

Speed categories		
Walking	0-7.2 km/h	0-2.0 m/s
Jogging	7.3-14.4 km/h	2.03-4.0 m/s
Running	14.5-19.8 km/h	4.02-5.5 m/s
High-intensity running	19.9-25.2 km/h	5.5-7.0 m/s
Sprinting	>25.2 km/h	>7.0 m/s

Based on this classification, it was possible to elaborate another table. In this second table, the distances covered are identified according to the displacement patterns, including not only total distances per match, but also their respective subtotals at the end of each part of football matches.

Table 4. Average distances covered by referees during football matches [36]

Distance			
	European championship	English league ($1^{st}/2^{nd}$/Total/Km)	Champions league ($1^{st}/2^{nd}$/Total/Km)
Walking	1.672/1.724/3.395	1.717/1.740/3.456	1.678/1.732/3.410
Speed-walking	2.343/2.302/4.645	2.468/2.370/4.838	2.627/2.542/5.170
Running	1.231/1.152/2.384	1.224/1.202/2.426	1.271/1.257/2.528
High-intensity running	0.388/0.363/0.751	0.364/0.371/0.735	0.367/0.374/0.741
Sprinting	0.059/0.042/0.102	0.057/0.059/0.116	0.056/0.059/0.115
Total	5.708/5.6/11.308	5.843/5.760/11.602	6.012/5.979/11.991

The distance covered, together with the type of displacement technique used, may constitute an overall indicator of the (physiological) exertion level that characterizes the performance of referees.

However, high-intensity actions, which are associated with the highest values of heart rate, are the best indicators of match play moments where fatigue sets in [34]. In fact, the total of high intensity efforts (and not the total distance covered) is more effective in identifying and classifying the development of fatigue throughout matches and, therefore, in identifying the varying levels of physical conditioning of referees as well [33, 35].

Referees vary as to the amount of running performed at high intensity. Referees capable of maintaining high-intensity running the longest are more effective in keeping up with match play [27]. This means that in order to be as close as possible to the players and the events that make up matches, referees need to have an adequate anaerobic capability [37]. Such portions of anaerobic effort are connected to physical conditioning, as well as to the reduction of the amount of aerobic effort experienced during match play. This suggests, for example, that referees are more capable of evaluating match play in the best possible manner [27].

The physiological elements that support the performance of referees include, as previously stated, aerobic metabolism, heart-rate values under 85% of maximum heart rate and anaerobic metabolism. While aerobic metabolism is correlated with the recovery phase that follows high-intensity efforts, anaerobic metabolism corresponds to phases where heart rate values exceed 85% of one's maximum heart rate [37].

Referees have very high average heart rate (HR), together with several moments that call for the use of anaerobic metabolism. This creates scenarios in which both metabolisms, aerobic and anaerobic, are solicited simultaneously [38]. Referees only exhibit repeated heart-rate values over 85% of their maximum heart rate (HR_{max}) during the first half of each match. Such episodes represent 62% of a referee's activity during the first half of a match and 45% during the second half, meaning that there is a reduction in the contribution of anaerobic metabolism towards the end of the match [38]. Additionally, studies on elite referees indicate that they spend more time performing under high-intensity conditions [5].

These arguments support the concept that the level of intensity characterizing the performance of referees varies both over the course of a match and over the course of the season [33].

Training, testing and evaluation of referees

After characterizing both the tasks and the demands involved in refereeing, one needs to provide referees with training in such a manner that they develop the ability to cope with the demands of a match, which entails successfully keeping up with the actions of the players [2]. Though it is necessary to consider referees independently of athletes, knowledge concerning the specific traits and demands of competitions should, as it happens with athletes, allow for the elaboration of training plans that match the specificity of this activity [39].

Referees can, over the course of football matches, show a reduction of their physiological output. This can occur after a high-intensity action, at the start of the second half and at the end of the match [40]. As a result, the process of planning the training of referees should include all available information that contributes to preventing or slowing down the setting in of fatigue [40].

On the other hand, training amongst elite athletes has integrated tactical skill, technique (coordination) and physical conditioning. Similarly, the training of referees should include conditioning routines complementing the development of the specific skills that make up refereeing [28]. Despite this, the training of referees is currently focused on physical conditioning, in the sense that it looks to reproduce the physiological conditions of match performance without including the decision-making tasks specific for refereeing. This training limitation can, nevertheless, be overcome by incorporating learning tasks in referees' training routines.

The absence of feedback pertaining to referees' training may help explain why it takes a long time for referees to reach an elite level [41]. More specifically, when it comes to decision-making skills, perception-centred skills may influence the number of

correct decisions. As it stands, perception errors, which are more common during the initial stages of referees' careers, can be reduced through long-term planning. Doing so may consequently facilitate the increase of correct decisions and, thus, refereeing quality, as shown by referees as they get older [42]. Contrary to this, some investigations reported that, in the context of referees' training, only their aerobic capability shows a slight adaptation and development as a result of the above-mentioned usual training routines and competitive activity [43].

It is worth mentioning that strength and power output decrease with age, which surely hinders sprinting capability and muscle efficiency amongst referees. As a result, training should also include the development of strength and power [5].

Though in training, greater emphasis is placed on aerobic metabolism, one cannot exclude the training of anaerobic procedures, agility and actions such as backward and lateral running [2]. Additionally, if displacement speed is to be similar amongst players and referees, the training of the latter should include drills that stimulate speed when changing the direction of one's displacement [44]. In short, coordinative skills can have a constraining effect on sport performance and, therefore, need to be included within the training process.

Given the training structure for aerobic metabolism, one should start by contemplating the selection of a training methodology that integrates drills of varying intensity and activity-specific drills [45]. Elite-level referees can attain an improvement of their match performance if their training includes drills of varying high intensity on top of aerobic-centred drills [27].

Speed output, together with its components of balance, coordination and power, affects the performance of athletes who need to make quick changes of direction. Improving agility benefits the enhancement of both body control (when changing direction as well as within linear-type speed drills) and muscle coordination (intra and inter), while also ensuring the lowering of injury frequency [46].

The enhancement of not only coordination but also of the interaction between the different forms of speed and strength (power) seems to be essential in improving the quality of one's ground contact (with the feet) and, as a result, of one's performance in changing direction when running [47]. By developing agility-related skills, athletes improve their balance and coordination. This, in turn, allows them to perform faster displacements as well as changes of direction that are both faster and more controlled [48]. Given that agility is considered to be the ability to change direction, stop or move forward quickly, its development and improvement is one of the most important elements that make up physical conditioning during the preparatory period [48], which applies equally to referees.

Referees (and especially elite ones) participate in a high volume of matches and training sessions. This means that the risk of sustaining an injury is the same during both match play and training [49]. Taking into consideration the physical demands and injury patterns characteristic of refereeing, as well as the prevalence and re-occurrence of myo-articular injuries, the planning and periodization of training should also include procedures for preventing injuries [1, 50].

Conclusions

The research goal defined for this study led to the identification of scientific articles published in peer-reviewed journals between 2000 and June 2017. For this purpose, we resorted to a methodology of systematic analysis based on (1) eligibility and exclusion criteria and (2) categorization of contents. Due to a lacking consensus on this issue amongst the main authors in this field, the latter was obtained using a mixed model. After analysing the selected articles, it was confirmed that the research conducted on the topic of refereeing has been rather scarce within the scope of the categories that were determined in our systematic analysis. Additionally, the publication of articles on this subject has been quite dispersed over the 15 years covered within our analysis.

Overall, a bottleneck effect occurred in the sense that research mostly focused on physiology, with few research efforts concerning other crucial areas such as the training and physical evaluation of referees, referees' perceptual-cognitive abilities and injuries.

The high number of articles dedicated to psychology and decision making (31 articles) fails to be duly matched by research concerning perceptual-cognitive abilities, as would be desirable.

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