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SYSTEMATIC REVIEW OF BASKETBALL REFEREES’ PERFORMANCES

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1 ABSTRACT

2 The importance of umpire during competition makes it essential to identify in
3 detail the referee's performance. The present study aimed to carry out a bibliographic
4 review that presents an analysis of the factors that influence a referee's performance, from
5 the physical/physiological, psychological and decisional points of view. The design was
6 centered on a systematic data review according to Preferred Reporting Items for
7 Systematic Reviews and Meta-Analyses (PRISMA). The data bases used for the review
8 have been WOS and SCOPUS. The inclusion criteria were: (i) Studies in English and
9 Spanish; (ii) Investigations on the physiological, psychological and technical profile of
10 basketball referees; and (iii) Relevant data on the performance of basketball referees
11 during competition. After the review process 51 articles were selected, classified into
12 three groups of variables: "Decision-Making" (16), "Psychological Demands" (15) and
13 "Physiological/Physical Demands" (21). The results show the importance and influence
14 of the basketball referee during competition and the need to work on their continuous
15 training according to the requirements of the game. Specifically, the referee must work to
16 improve in three principal aspects: decision-making (knowledge of the rules, their
17 application during the competition, the mechanics of movements or the control of the
18 game in situations of conflict or stress); physical/physiological condition (HR, Distance
19 Covered, Speed, PlayerLoad or METs) and stress situations (referee errors, protests,
20 abuses or game adjusted). All of the above, should be related with the experience and
21 competence that all referees should acquire to be able to develop their functions as
22 successfully as possible, using the different tools and methods detailed in the studies
23 analyzed to help them to improve their vision and their role in competition.

Keywords: Basketball Refereeing, Decision-Making Profile, Physiological Profile and Psychological Profile.

1. INTRODUCTION

In the sports context, the role of the referee is gaining increasing importance in the development of competition (Louvet et al., 2009), as without his or her presence it is currently complicated to enforce the rules of each sport. Each sports discipline presents different characteristics in its rules, but all of them are focused on facilitating the development of the game and sanctioning the infractions that hinder its correct evolution. Due to the evolution of sport (Allegretti et al., 2015; Ibáñez et al., 2018) and professionalization of their role, referees need a series of skills, knowledge and attitudes that enable them to carry out their functions accurately and correctly (García-Santos & Ibáñez, 2016), and even more so, if they are the center of attention (of players, coaches and spectators) in the conflictive situations that arise in every game in the different competitions (Pedrosa & García-Cueto, 2015; Karacam & Adiguzel, 2019). Therefore, referees need continually to have better training from the physiological, psychological and technical-tactical points of view (García-Santos et al., 2017), that permits them to improve their experience, self-efficacy (Myers et al., 2012) and refereeing judgement (Dosseville et al., 2011; Pizzera & Raab, 2012).

In basketball, as in other sports, the referees have to make decisions within milliseconds, so that it is important for them to work and prepare themselves to face this type of situations, to achieve an adequate performance during the competition that makes it possible for them to be more competent in their functions (Guillén & Feltz, 2011). Different variables influence the decision-making (Ahmed et al., 2017) and performance of the referee (García-Santos et al., 2017), as well as tools that make it possible to quantify

1 them. The most commonly studied variables in referees have focused on analyzing
2 physiological demands, like heart rate (HR) (Leicht, 2008; Matković, et al., 2014;
3 Vaquera et al., 2017), kinematic variables like distance covered, speed, etc. (Allegretti et
4 al., 2015; Borin et al., 2013; Nabli et al., 2017; García-Santos et al., 2019), or
5 neuromuscular variables (Bonganha et al., 2013; García-Santos et al., 2019; Leicht et al.,
6 2019). Similarly, there are studies centered on analyzing the psychological demands and
7 stressful situations during competition (Cantón et al., 2011; Ramírez et al., 2006; Slack
8 et al., 2013; Anshel et al., 2014). Lastly, there are studies that analyze the situational and
9 technical variables of refereeing itself (García-Santos & Ibáñez, 2016; García-Santos et
10 al., 2017), as it is essential to understand the way that the rules have to be enforced.

11 Several tools or methods are available to analyze and quantify these variables.
12 Regarding the physiological aspect, HR monitors have commonly been used, as well as
13 the subjective rating of perceived exertion (RPE) using Borg's CR-10 scale (Borg, 1982),
14 due to their low cost and easy handling. Currently other methods are being used to assess
15 the physical performance of referees more precisely like video-based-training (VBT)
16 (Allegretti et al., 2015; Nabli et al., 2017), global positioning system (GPS) (García-
17 Santos et al., 2017) or inertial devices with Ultra-WideBand (UWB) technology that
18 permit measurement of indoor sports (García-Santos et al., 2019). In the psychological
19 context there are questionnaires focused on determining efficacy, stress, anxiety, etc., like
20 the LISEA questionnaire (Jaenes et al., 2012), which is specifically for basketball
21 referees. It is also important to analyze the technical and mechanical part of the referee's
22 movement, for which there are instruments like the IOVAB (Observational Instrument to
23 Basketball Referee Evaluation) (García-Santos & Ibáñez, 2016), that assesses the
24 performance of the referee during the competition.

Given this scientific panorama, there is a need to collect together the different studies and carry out a more detailed analysis of the performance of basketball referees, therefore the aim of the present systematic review was to analyze the existing literature on basketball referees' performances according to the physiological, psychological and decision-making demands of competition. In order to establish adequate training program for the needs of the referees and competition.

2. METHODS

2.1 Design

The present study is a review of the literature on basketball referees, using a systematic retrieval of data and study selection processes (Ato et al., 2013). The aim was to analyze and learn about existing research centered on the study object.

2.2 Search Strategy

The success of a good literature review lies in adequate planning (Thomas et al., 2015). Establishing the strategies and steps to be followed makes it possible to draw relevant conclusions. The literature search process used in the present study is shown in Figure 1.

*****Figure 1 near here*****

The electronic bibliographic search was carried out during the month of October 2019, collecting all the articles found up to that date in the Web of Science (WOS) and Scopus databases. The keywords used for the search were "Basketball Referee", associated in each case with the following words: "Performance", "Stress", "Decision-making" and "Physiological Demands". The search was made both in Spanish and English.

The systematic literature review followed the proposal of Sarmento et al., (2018), according to the guidelines determined by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (Moher et al., 2009; 2015), where the review selection process was divided into four phases: a) Identification, b) Screening, c) Eligibility and d) Inclusion (Figure 2).

Figure 2 near here

2.3 Inclusion and Exclusion Criteria

The inclusion criteria used for the articles were: (i) Studies in English and Spanish language; (ii) Research on the physiological, psychological and technical profile of basketball referees; and (iii) Performance data of basketball referees during competition.

The exclusion criteria were: (i) Articles about referees from other sports; (ii) Research carried out outside of the competitive framework; (iii) Variables that did not coincide with the review topic; and (iv) Abstracts from congress presentations.

2.4 Variables

The articles that fulfilled the inclusion criteria were classified into three main groups of variables: “Decision-making”, “Physiological/Physical Demands” and “Psychological Demands”. This classification was made after analyzing the variables present in the retrieved texts, as there could have been duplicates in the search according to the keywords or articles which once read did not coincide with the keywords. The following variables were detailed for each study: author/s & year, sample (level, gender, number of subjects and number of games or cases), aim, variables, main results and quality score.

2.5 Data Extraction and Quality

A table drawn up by Law et al. (1998), was used to assess the quality of the studies. It is composed of 16 items that measure the quality of the methodology (Table 1). The score for each item follows a binary scale (0/1) where 0 is for a negative answer and 1 for an affirmative answer. There are two items (6 and 13) which were not applicable to all the studies, and therefore the option NA (not applicable) was included. The sum of all the positive items from the total number of items was used to indicate the quality of the study. According to the score, the articles were classified as of low methodological quality (<50%), good methodological quality (51-75%) and excellent methodological quality (>75%) (Sarmiento et al., 2018).

Table 1 near here

2.6 Reliability

Two reviewers who had experience in the analysis of document reliability calculated the reliability of the data according to the Quality Score (QS). To achieve an adequate reliability of the data it is necessary to carry out a reliability analysis of at least 10% of the study sample, and in this case a total of 5 articles was analyzed. The inter-rater analysis was performed with Cohen's Kappa (Randolph, 2005), obtaining a value of .891. This is defined as "almost perfect" reliability as indicated by Landis and Kolch (1977), as it is between the values of 0.81-1. These authors establish different categories: <0.00 (Poor); 0.00-0.20 (Slight); 0.21-0.40 (Fair); 0.41-0.60 (Moderate); 0.61-0.80 (Substantial) and 0.81-1 (Almost Perfect).

2.7 Data Analysis

Initially a descriptive analysis was performed on the selected studies detailing the type of sample (level, sex, number of subjects and number of games or cases), the object

of study, the studied variables, the main results and the quality of the study (see Tables 2, 3 and 4). Subsequently, an analysis of the contingency tables was carried out to observe the relations among the type of study, level and different variables related to the three main groups established (see Table 5).

3. RESULTS AND DISCUSSION

The aim of the present study was to draw up a systematic review on the performance of basketball referees. For systematic reviews it is important to select suitable keywords, and to develop a methodological process which is adequate for the characteristics of the study. (Ato et al., 2013). The results show that basketball refereeing has been analyzed from several viewpoints: technical demands using decision-making, physiological demands related to internal and external load, and psychological demands, especially focused on different stressful situations.

3.1 Search, Selection and Inclusion of Publications

A total of 231 articles was identified in the WOS and SCOPUS data bases which were divided into three large groups of variables. Some of the references were duplicates and were eliminated, leaving 174 investigations. After reading the abstracts only 105 articles remained of which 70 were examined in detail: Decision-making=24, Physiological/Physical demands=25 and Psychological demands=21. After an in-depth reading of the different articles a total of 52 documents remained in the final review: 16 on decision-making, 15 on psychological variables and 21 on physical/physiological load variables (Figure 2). The main exclusion factors of the studies were that they were congress presentations (n=5) or the topic of the research did not coincide with the subject of study (n=5).

3.2 Quality of the Studies

After analyzing the inclusion and exclusion criteria of the different studies in the present review, the selected articles are described in detail according to the study variables. The studies presented a high methodological quality (Figure 3), with the highest percentages corresponding to the studies related to the variables of physiological/physical load (83.42%), followed by those on decision-making (79.20%), and lastly those referring to psychological demands (78.97%).

Figure 3 near here

3.3 Decision-Making

Regarding referees' decision-making a total of 16 articles was analyzed in depth showing excellent methodological quality (79.20%) (Table 2). Decision-making is of extreme importance for a basketball referee's performance, as there are a multitude of situations or moves that need to be assessed and that influence the development of a game. According to the different studies found, there are tools which make it possible to evaluate referees' technical performance or improve their decision-making, like the IOVAB (García-Santos & Ibáñez, 2016); the BOFQ questionnaire (*Basketball Officials' Favoritism Questionnaire*) (Gencay et al., 2015); the FOLQ questionnaire (*Functions of Observational Learning Questionnaire*) (Hancock et al., 2011) and the BBFBR program (*Basketball Board for Basketball Referees*) (Markoski et al., 2011). The most important aspects of each one is described below. The IOVAB tool analyzes the movements that the referee makes during the competition according to the refereeing mechanics, violations, fouls, collaboration with companions and control of the game. The use of this instrument requires the evaluation on the part of experts or technical referees visualizing the match in real time or from a recording to obtain a precise and detailed value judgement. It is also possible for the referees themselves to carry out a self-evaluation at

1 the end of the match, to ascertain their own perception of their performance and compare
2 it with the evaluation of the technical referee.

3 The BOFQ questionnaire expresses the influence or the degree of favoritism that
4 the referees present in their decisions depending on the team, players or coaches. It also
5 observes the pressure that the public can exert on their decisions during the game.

6 The FOLQ questionnaire evaluates through different questions what variable is
7 the most important for a basketball referee. The variables presented are: technical skill,
8 strategy or reading of the game and the performance (correct or incorrect decisions) in
9 the different game situations. The results are also compared with the players and coaches.

10 Lastly, the BBFBR program presents a series of real game situations using a video
11 which makes it possible to train referees' in decision-making. It is a viable tool to place
12 the referees in different situations which they will later have to solve on-site during
13 games.

14 There are also studies that analyze the degree of influence of the players, coaches,
15 teams or spectators in referees' decision-making, according to the anthropometric
16 characteristics of the players, their reputation and that of their teams, the position that the
17 team occupies in the ranking or whether they are playing at home or away or the pressure
18 that the stands can apply on the refereeing staff (Morgulev et al., 2018; Gencay et al.,
19 2015; Gift & Rodenberg, 2014; Anderson & Pierce, 2009). Similarly, the referees have
20 to be able to live with their mistakes (McMahon & Mildenhall, 2012) and recognize their
21 limitations, developing selective attention (Hack et al., 2009) which permits them to tune
22 out situations that are unrelated to the game and improve their efficacy in the competition
23 (Karacam & Agudizel, 2019). Another aspect to highlight in decision-making is the level
24 of refereeing competence or category and sex, which are better when the referees are more

experienced (Gencay et al., 2015), while sex does not influence decision-making (García-Santos et al., 2017). These results determine the importance of training and improving decision-making using different tools that help to reduce the error rate and make it possible to adapt to the different situations that competition provides with the best possible chances for success, **developing a good refereeing self-efficacy (Myers et al., 2012) and a positive perception by the players, coaches and spectators.** Therefore, an analysis of referees' decision-making is very important for their progress and efficacy (García-Santos & Ibáñez, 2016). To this end, **it is possible to determine different training programs that improve the referee's decision making, such as reviewing game conflictive situations and their possible solutions or proposing real situations where the referee have to make the best possible decision with a limited time.** Figure 4 shows the most important aspects to take into account for a correct referee decision-making, **according to the different studies (n=16) included in this review, that were conducted on the decision making of basketball referee.**

*****Figure 4 near here*****

*****Table 2 near here*****

3.4 Physiological/Physical Demands

Table 3 shows the results regarding the variable “Physiological/Physical Demands”, showing that after the methodological processes were performed a total of 21 articles were reviewed with a quality score of 83.42%. This group includes the variables of physiological and physical loads. The method for measuring physiological load most commonly used, due to its ease of use and low cost, is HR. According to different studies (Nabli et al., 2019), basketball referees during the game usually have HR values between 70-80% of their HRmax. This variable has been related in several studies with body

composition (Vaquera et al., 2017; Vaquera et al., 2016; Leicht, 2002), where it is not shown that an improvement in HR produces an improvement in anthropometric values. Similarly, HR has been studied according to the gender of the referees, showing that the men referees record higher values (Vaquera et al., 2016) or according to age (Matkovic et al., 2014), where there were no significant differences among the referees. HR variability has also been studied during different periods of the game, and were found to be similar during the whole game (Nabli et al., 2016; Rupcic et al., 2012; Leicht, 2008). It is even possible know the difference depending on the level or category of the game, where it exists higher values in international categories (Leicht, 2004; 2008; Nabli et al., 2019) or if it is a championships, it is possible to observe differences between the first phases of the tournament and the final phases where the title is being played. In this case, the title games present higher values (Borin et al., 2013; Nabli et al., 2019). Similarly, the refereeing system (2 or 3 referees per game) can influence HR values, being higher in those competitions or games where it is refereed with two referees (Nabli et al., 2019). Therefore, these results show that HR does not determine the referee's performance, as it is usually constant during the game, but it is advisable to monitor the referee's HR to confirm that it is within normal values and the referee is not suffering from some type of anomaly.

There are other studies that have analyzed other types of physiological load, like the blood lactate concentration (Nabli et al., 2016; Nabli et al., 2016; Borin et al., 2013) or the RPE (Vaquera et al., 2017), neither of which showed significant values during the different quarters of a game. Although neither of the two variables showed significant values with regard to performance, it is advisable to use the RPE rather than the analysis of lactate in the blood, as it is a non-invasive and cheaper.

Regarding the physical load, studies have been found on time-motion analysis during the game and the distance covered by a basketball referees is around 1,200 meters per quarter (Allegretti et al., 2015; Borin et al., 2013; García-Santos et al., 2019; Nabli et al., 2016), where 60-70% walking, about 2% sprinting and the rest jogging or running. It is also worthy of note that 87% of the time they are making short lateral movements. Specifically, the highest maximal speed reached by the referee was around 19km/h during transitions or sprint actions (García-Santos et al., 2019). Likewise, a basketball referee usually performs around 4,500 accelerations and 3,800 decelerations per game (García-Santos et al., 2019b). So that for referees to improve their physical fitness they should train according to the characteristics of the competition, thus it is possible to state that training repeat sprint ability (RSA) enhances the referees' fitness (Bayón et al., 2015). It is also necessary to understand the referee's energy expenditure during the game, which in the case of the basketball referee is predominantly from aerobic metabolism (Nabli et al., 2017) with a workload around 44PL (García-Santos et al., 2019), and always below the workload reached by the players (Leicht et al., 2019). Thus, for referees to improve their physical/physiological profile they should focus on their own physical and physiological condition and carry out fitness programs adapted to the needs of the competition, where game conditions are reproduced. According to the researchers analysed, the figure 5 summarises the basketball referee's physical/physiological fitness profile, highlighting the main factors could affect of each game (the HR, the time motion analysis and the workload profile).

Figure 5 near here

Table 3 near here

3.5 Psychological Demands - Stress

Table 4 presents the studies that analyzed psychological variables. A total of 15 investigations were identified with excellent methodological quality (78.97%) (Sarmiento et al., 2018), focused basically on the variables associated with stress. Some of the studies created tools that measure stress (De Almeida et al., 2018; Anshel 1995; Stewart et al., 2004; Jaenes et al., 2012; Anshel et al., 2013; Anshel et al., 2014), others observed stress using these tools in competitive situations (García-Santos et al., 2017; Ritchie et al., 2016) or with the visualization of different stressful moves using a monitor (Anshel & Weinberg, 1995; Kaissidis-Rodafinos et al., 1997; 1998; Kaissidis-Rodafinos & Anshel, 2000). Moreover, these studies analyze the differences among referees, with regard to gender, with women being more affected (García-Santos et al., 2017), to the referee's level, with the novice referees recording the most stress (Kaissidis-Rodafinos & Anshel, 1993; Anshel & Weinberg, 1995; Ritchie et al., 2016) or the referee's nationality: Turkish (Anshel et al., 2014), Greek (Kaissidis-Rodafinos & Anshel, 2000), American and Australian (Anshel & Weinberg, 1995) and Greek and Australian (Kaissidis-Rodafinos et al., 1998). The most stressful situations for the referees in these studies were: when the referee instructor was present at the game, when there were mistakes in the officiating mechanics, when a foul has been erroneously called, when there was an injury, when there were protests by the players or coaches, and lastly, when the instant replay was used. So, it is necessary to work on all these types of situations to be able to reduce the stressful events in competition. As stated by Rainey & Winterich (1995) and Stewart et al., (2004) about 5% of the situations that arise in a game cause high values of stress, while the normal development of a game presents low or medium values. It is possible to attribute these high values of stress to important situations during the competition which may decide the result of the game, like for example the moves analyzed on instant replay, or

1 protests like physical or verbal abuse that lead to players or coaches being disqualified or
2 sanctioned with technical fouls. Therefore, working on this type of situation will make it
3 possible to reduce the referees' stress rates and help them to learn to live with their
4 decision-making mistakes or conflict situations. The figure 6 figures out the stressful
5 situations that the referees have to deal with during a game.

6 ***Figure 6 near here***

7 ***Table 4 near here***

8 **3.6 Multidimensional Analysis**

9 After the analysis of each of the selected studies, Table 5 presents the relations
10 that exist among the type of study (*decision-making, physical/physiological demands and*
11 *psychological demands*), the level of the referee (*international, national, regional,*
12 *training, experts and mixed*) and the different variables found in each of the studies.
13 Within the decision-making group it can be seen that the most influential variables are
14 those related with the success of the decisions made, the technical skills of the referee,
15 the variables associated with the competition (result, score, end of game...), the
16 characteristics of the players (large players, skilled players, the best player in the team...)
17 and the teams (local, visitor, position in the competition ranking...) (Morgulev et al.,
18 2018; Gift & Rodenberg, 2014) and of course the knowledge the referee has of the game.
19 All these variables influence to a greater or lesser extent the decision-making of the
20 referees, independently of their level (international, national, regional, training or
21 experts), sex (García-Santos et al., 2017) or age, there are even studies that assess these
22 variables comparing them among referees of different categories (Alker, 1973; Gencay et
23 al., 2015).

1 In the studies related to the physical/physiological demands the majority are associated
2 with analyzing HR, independently of the referee's category (Nabli et al., 2019), age
3 (Matkovic et al., 2014) and sex (Vaquera et al., 2016). Moreover, they have studied the
4 relation between the referee's body composition and the competitive load (Leitch, 2002;
5 Vaquera et al., 2017), as well as the distance covered by the referee during the different
6 quarters and during the game (Allegretti et al., 2015; Borin et al., 2013; García-Santos et
7 al., 2019; Nabli et al., 2016) and the energy spent during the competition (Nabli et al.,
8 2017). To a lesser extent there are studies related to lactate (Nabli et al., 2016), no doubt
9 due to the complexity of performing them and the impact they have on the referee. Lastly
10 there are a few studies focused on the referee's neuromuscular variables (Bonganha et al.,
11 2013; García-Santos et al., 2019; Leicht et al., 2019), which are currently of great interest.
12 However, no studies have been found that relate load parameters with competitive
13 variables, the characteristics of the players and teams, or the success or failure of the
14 decision-making. A surprising situation, since it would be helpful to observe the relation
15 among the competitive variables, decision-making and the physical/physiological
16 demands experienced by the referee. It would also be interesting to know how the
17 different stressful situations that arise in competition affect the values of
18 physical/physiological load.
19 Finally, the research associated with the psychological profile is closely related to the
20 different stressful situations (protests, errors, conflictive situations...). Similarly, this type
21 of variables is influenced by the characteristics of the players and teams, as well as the
22 correctness or not of the decision-making which may trigger conflictive situations. If we
23 consider the level of the referees in these studies we find research exclusively focused on
24 national referees (Jaenes et al., 2012) and those in training (García-Santos et al., 2017;

Ritchie et al., 2016) and in other cases, comparing their level (international, national and in training) (Arbinaga et al., 2019; De Almeida et al., 2018) and even different nationalities (Anshel & Weinberg, 1995). This is an interesting aspect, as it can be observed that the novice referees present higher values in stressful situations (Ritchie et al., 2016), as they are not so used to living with their mistakes (McMahon & Mildenhall, 2012), neither to endure the different protests that can arise.

Table 5 near here

4. CONCLUSIONS

The present study made it possible to carry out a detailed analysis of the literature devoted to the basketball referee in the SCOPUS and WOS databases. The findings have led to the establishment of three main groups of variables that determine the referee's performance during competition.

To be able to make correct decisions referees have to develop a series of technical skills associated with the assessment of contacts, violations, the control of the game or the mechanics of the movements that determine the success of their intervention in the game. In addition, it is necessary that the referee made a training program simulating the real game conditions so that his decision-making is adapted to the real-time space and to solve different situations that can arise in a basketball game.

It is also necessary to take into account the variables of physiological and physical load that indicate the level of effort and the physiological characteristics of the referee during the development of the game. According to the analysed studies it is possible to enhance the importance of HR, kinematics variables (speed, distance covered, accelerations and decelerations) and neuromuscular variables (player load and metabolic

energy). In addition, it is needed of controlling for referee's anthropometric measures that may affect his/ her movements and actions.

Lastly, it is important to identify and define the different stressful situations that can arise in competition, to be able to counteract them and live with them during the referee's intervention. After the systematic revision, the specify situation are the referee's mistake, the presence of an observer or technician, rough situation between players, players, coaches or fans protesting, and end of game situations solved via IRS (Instant Replay System) or after a referee's consensus.

All of the above, should be related with the experience and competence that all referees should acquire to be able to develop their functions as successfully as possible, using the different tools and methods detailed in the studies analyzed to help them to improve their vision and their role in competition.

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DECLARATION OF INTEREST STATEMENT

The authors report no conflicts of interest.

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Table 1. *Quality Score of Investigations (Law et al 1998)*

<i>Q1</i>	Was the study purpose stated clearly?	1=Yes	0=No
<i>Q2</i>	Was relevant background literature reviewed?	1=Yes	0=No
<i>Q3</i>	Was the design appropriate for the research question?	1=Yes	0=No
<i>Q4</i>	Was the sample described in detail?	1=Yes	0=No
<i>Q5</i>	Was sample size justified?	1=Yes	0=No
<i>Q6</i>	Was informed consent obtained? (if not described, assume No)	1=Yes	0=No If not applicable, assume NA
<i>Q7</i>	Were the outcome measures reliable? (if not described, assume No)	1=Yes	0=No
<i>Q8</i>	Were the outcome measures valid? (if not described, assume no)	1=Yes	0=No
<i>Q9</i>	Was method described in detail?	1=Yes	0=No
<i>Q10</i>	Were results reported in terms of statistical significance?	1=Yes	0=No
<i>Q11</i>	Were the analysis methods appropriate?	1=Yes	0=No
<i>Q12</i>	Was importance for the practice reported?	1=Yes	0=No
<i>Q13</i>	Were any drop-outs reported?	1=Yes	0=No If not applicable, assume NA
<i>Q14</i>	Were conclusions appropriate given the study methods?	1=Yes	0=No
<i>Q15</i>	Are there any implications for practice given the results of the study?	1=Yes	0=No
<i>Q16</i>	Were limitations of the study acknowledged and described by the authors?	1=Yes	0=No

Table 2. Decision-Making Studies.

Authors & Year	Sample		Number of Subjects	Number of Games/ Cases/Seasons	Aim	Variables	Main Results	QS (%)
	Level	Gender						
Karacam & Adiguzel, 2019			64		To examine the relationship between performance scores and basketball referees' self-efficacy levels with some demographic variables	Self-efficacy scale and demographic variables (age, experience, n° games, score)	A positive significant relationship was found between basketball referees' physical fitness, game knowledge, decision-making, pressure, communication, REFS total score, and their performance scores and the variables age and the number of games refereed. Moreover, a positive significant relationship was found between basketball referees' physical fitness, game knowledge, decision-making, pressure, communication, and REFS total score and their performance scores.	78.6
Morgulev et al., 2018.				250 cases	To analyze the reason for calling fouls in attack	Difference in the body composition of the players, reputation of the player, reputation of the team, situation of the team (local or visitor).	There were no significant differences regarding this type of variables to call a foul in attack or legal position defense.	71.4
García- Santos et al., 2017.		4 M 2 F	6		To understand the differences in relation to the gender of the referees in their intervention in the game.	IOVAB. Uniformity and fitness, mechanics, violations, personal fouls, collaboration with the companion and control of the game.	There were no significant differences in any of the blocks, except the mechanical movements of the head referee that are performed better by the women.	80.0
García- Santos & Ibáñez, 2016.	14 Experts		14		To elaborate and validate an instrument to assess a referee's performance (IOVAB).	Uniformity and fitness, mechanics, violations, personal fouls, collaboration with the companion	The results on validation and reliability show that it is only necessary to eliminate 6 items of the 50 that compose the instrument. The final document was found to be valid and reliable to be applied to referee training.	92.9

				and control of the game.		
Gencay et al., 2015.	76	To ascertain the influence of teams, players and spectators on referees' decision-making.	The Basketball Officials' Favoritism Questionnaire (BOFQ)	The present paper has also revealed that basketball officials with positive sporting backgrounds (experience as players at professional or amateur level) are less affected by spectators. There were, however, no correlations found between the years of officiating experience and the factor of influence of individual players, teams and spectators.	100	
Gift, 2015	6.538 games	This study investigates the impact of past performance evaluations on future decisions involving judgment. It analyzes the decisions of highly skilled and highly monitored referees regarding offensive fouls and violations in the National Basketball Association.		Results are inconclusive for subsequent changes in scrutiny toward the original violating team. The analysis provides a non-experimental test of sequential bias on elite employees working under strict performance standards, and suggests a likely role for sequential judgment effects in other areas of economic activity.	85.7	
Gift & Rodenberg, 2014.	4 seasons	The interaction between players and referees in the National Basketball Association (NBA) provides a real-world laboratory that allows for observation and testing of implicit height-based biases	Referee Height, Player Characteristics and Player Performance Statistics.	They find evidence that referees exhibit height-related bias in their personal foul calls in a manner resembling the Napoleon Complex. We also find that increased foul calling by shorter referee crews does not vary with player height. This finding may be true in an absolute sense or it may be a function of our sample, which does not contain a substantial number of players who are shorter than the referee crew.	85.7	
McMahon & Mildenhall, 2012.		The objective of this article is to reflect on the sport science research findings related to decision-making and	Decision-making errors	Specifically, it reflects on the mechanisms that have been discussed as influential in leading to these errors, and the responses to these errors. It presents the general view that officials are human information processors	64.3	

				decision-making errors in sports officials (judges, umpires, referees).		both vulnerable to, and in some cases benefitting from, the limitations of their system.	
Hancock et al., 2011	14 M 6 F	20		The purpose of this research was to investigate patterns of observational learning implemented by team sport athletes, coaches, and officials.	The FOLQ evaluates three functions of observational learning (skill, strategy, and performance)	Coaches scored highest on the skill and strategy functions, while officials scored highest on the performance function. Another contribution is the confirmation that observational learning is not influenced by gender or level.	92.9
Markoski et al., 2011				To develop software for decision-making in Basketball.	BBFBR Program	The current version of the BBFBR solution has implemented only a simple computation of the optimal path for the basketball referees in some actions. Therefore, it currently has only an educational purpose, which means that it can be used for training young basketball referees.	64.3
Anderson & Pierce, 2009.			365 games	To determine if the team and the number of fouls affects sanctioning a subsequent foul.	Fouls, Home Team, Away Team.	Results of the analysis indicate that officials are more likely to call fouls on the team with the fewest fouls, making it likely that the number of fouls will tend to even out during the game. This increased probability augments as the foul differential rises. In addition, there is a significant bias towards officials calling more fouls on the visiting team, and a bias towards foul calls on the team that is leading. The result is that the probability of the next foul being called on the visiting team can reach as high as 0.70.	71.4
Hack et al., 2009	20 M	20		This study examined attention processes in complex, sport-specific decision-making tasks without interdependencies from anticipation. Psycho-physiological and performance data	Event-related potentials obtained while judging game situations in foul recognition and a control task provided insight into focus of attention, selective attention, and	Results showed task-specific effects for advanced referees in components influenced by attentional focus and selective attention. Experts also seemed to profit from superior top-down strategy and were able to evaluate the stimuli more rapidly. These findings are discussed in connection with current models in neurosciences and theories of referee research.	85.7

				recorded from advanced and intermediate level basketball referees were compared.	processing strategy (top-down vs. bottom-up).		
	Rodenberg & Lim, 2009.	77	654 games	To analyze if the referees had negative effects on the performance of the Dallas Mavericks.	z-Score	It found that no NBA referee had a significant adverse effect on team performance or exhibited bias against the Dallas Mavericks when considering all games (regular season and playoffs). However, when analyzing only the 80 playoff games involving the team, one example was found of an NBA referee having a significantly adverse effect on team performance.	71.4
	Brand et al., 2006.	121		Referees had to make foul decisions for each of 18 videotaped scenes (contact situations).	Decision-Making	Results showed that referees in the condition with the removed sequential context awarded more rigorous sanctions than their colleagues.	71.4
	Proios & Doganis, 2003.	55		The purpose of the present study was to investigate the effect of experiences of active membership and participation in decision-making processes and age on moral reasoning and goal orientations of referees in sport.	The Defining Issues Test and the Task and Ego Orientation in Sport Questionnaire. Experience and Age	The examination of mean scores did not show any specific trend of Task and Ego Orientation scores among referees in relation to age. No significant correlations between age and Task and Ego Orientation were found. The results were similar for Experience, with no apparent Goal Orientation trend. Again, no significant correlation between Experience and Task and Ego Orientation were found. Examination of mean P-scores by age, showed lower scores for adolescents (17 years of age) and higher ones for groups of adults up to 27 years of age and lower means for subjects older than 27. Finally, there appears to be an increase in the values of P scores by Experience. However, the correlations among age, experience, and P scores were not statistically significant	71.4
	Alker et al., 1973	223	20 NBA 72 HG 69 MG 62 LG	This study investigates the characteristics of professional basketball referees which can account for their successful or	California Psychological Inventory (CPI).	There are more statistically significant variance differences between the groups of referees than there are mean differences on the CPI scales. These significant variance differences with one exception (Social presence) all exhibit the largest variance in the bottom rated officials. Dominance, responsibility,	80.0

unsuccessful performance
on the court.

sense of well-being, and achievement via conformance
exemplify this trend.

Note: *QS=Quality Score; M=Male; F=Female; HG=High Level; MG=Medium Level; LG=Low Level*

Table 3. *Physiological and Physical Demands Studies.*

Authors & Year	Sample Level	Gender	Number of subjects	Number of games/cases	Aim	Variables	Main Results	QS (%)
García-Santos et al. (2019)	International	6M 3F	9	15 games	The aim of the study was to analyzed the acceleration profile of basketball referees through UWB technology.	Accelerations and Decelerations during different periods of the game.	The results show that there are significant differences between the first and the fourth period in the duration of accelerations and decelerations and in the start speed of decelerations. Acceleration basketball referees profile can meet the demands of the game and properly analyze the predictors of performance.	86.7
García-Santos et al. (2019)	International	6M 3F	9	15 games	The purpose of this study was to identify the physiological, internal, and external demands placed on basketball referees using ultra-wideband (UWB) technology, in relation to the period of the game.	Internal and External Load	The results exposed that referees work around 62% HRmax and spend more than 80% of the game at intensities between 0–12 km/h. The first period was the period in which the greatest work demand was experienced in relation to these neuromuscular outcomes (11.92 PL; 3.61 Met; 277 Impacts). The results revealed a diminishment of internal and external demands on the referees over the course of the game.	93.3
Leicht et al. (2019)	National	2M 1F	3	1 game	The aims of this brief report were to: 1) document the activity demands of sub-elite basketball referees during a game; and 2) compare referee and player game activity demands.	External Activity: Player Load	Referees experienced an absolute PL of 310 ± 28 arbitrary units (4.2 ± 0.4 AU.min ⁻¹) during the game which was ~40% lower than that of the players. Referees exhibited a game PL profile dominated by the lowest PL band (~91%) with the players' PL profile shifted slightly towards higher bands.	73.3

Nabli et al., 2019 (Review)

The aims of the present narrative review were to summarize knowledge in exercise performance of basketball refereeing to help practitioners develop sports training programs and select appropriate testing, and to support researchers developing new studies in this field.

Physiological demands
Physical demands
Decision-making
Mental fatigue
Experience

The relevant studies (n=19) showed that referees cover ~5000 m during a game with mean HR of ~140 beats.min⁻¹ (>75% HR_{max}) and oxygen uptake of ~52 ml.min⁻¹.kg⁻¹ (~86.19% VO₂max). The YO-YO intermittent recovery test level 1 (YO-YO-IRT1) performance has revealed a direct validity to assess the intermittent aerobic activity as it was correlated to the on-field activity of the referees. The estimated referees EE during a game exceed 500 kcal (~5 kcal.kg⁻¹.h⁻¹). The threshold of low intensity and high intensity could be considered as lower than 3.8 METs and higher than 9.8 METs, respectively. The physical abilities of referees decrease gradually with the chronological age. However, older referees (>32 years old) have a significantly better quality of officiating than young referees. The perceptual cognitive demands of basketball refereeing are also discussed in the present review

85.7

Vaquera et al., 2017. International

F

10

11

The current aims were to determine BC, and HR and RPE responses by female basketball referees during elite international competition.

BC, HR, RPE and experience.

The current investigation has demonstrated that elite female basketball referees experience significant cardiovascular and perceptual stress during international games that may be influenced by referee experience and BC.

86.7

Nabli et al., 2017 International

M

16

The aim of this study was to analyze the EE and the exercise intensity of basketball refereeing during an official game and determined as METs.

EE; METs, Time Motion Analysis.

During a game, referees spent a mean EE of 504.4 ± 77.7 kcal. A significant difference was observed between 113.5 ± 18.2 kcal in the 1st quarter and 137 ± 27.5 kcal in the 4th quarter (p<0.00). The averaged EE (~5 kcal.kg⁻¹.h⁻¹) corresponded to “moderate energy intensity” (~5 METs) with a large contribution of the aerobic energy pathway. In all, during 88% of the game the intensity was equal or lower than

86.7

Nabli et al., 2016.	16 International	M	16		This study aimed to examine the physical and physiological demands of basketball refereeing.	HR, Lactate and Distance covered.	Blood and	3.8 METs and in 12% it was higher than 9.8 METs which were considered as low to high-intensity thresholds, respectively. The energy profile studied in this research confirms that basketball refereeing may be regarded as a clearly intermittent-activity mode with a predominantly aerobic metabolism solicitation. Referees spent more time ($p<0.01$) walking (63.72 ± 2.02 min) than jogging (3.10 ± 0.29 min), running (4.24 ± 0.46 min) and sprinting (1.69 ± 0.24 min). Referees covered more distance ($p<0.01$) walking than jogging, running and sprinting across the quarters. Mean HR (74.89 ± 6.86 %HRmax) was not significantly different across the game 1 st quarter to 4 th quarter) and halves. [La] did not show significant changes when comparing the half-time (4.30 ± 3.92 mmol.L ⁻¹) and the end of the game (6.70 ± 4.90 mmol.L ⁻¹).	93.3
Nabli et al., 2016.	15 National	M	15	8	To examine the relation between game performance, physiological responses, and field-test results in Tunisian basketball referees.	Time-motion analysis, HR and Blood Lactate, Yo-Yo Test.		This study showed that (1) the YYIRTL1 performance is a moderate predictor of game physical performance in U-19 basketball referees and (2) referees' RSA correlates with the amount of HIA performed during the 2nd half, which represents the ability to keep up with play.	80.0
Vaquera et al., 2016.	27 International	18M 9F	27	18 games	The aim of this study was to investigate the impact of sex on cardiovascular responses of referees during elite international basketball competition.	Average relative exercise intensity.	HR,	Female referees exhibited lower average game HR (156.8 ± 10.2 vs. 163.6 ± 11.6 bpm, $p<0.05$) and exercise intensity (86.2 ± 5.5 vs. 89.5 ± 6.0 %HRmax, $p<0.05$) compared to male referees.	86.7
Vaquera et al., 2016.	31 International		31	38 games	The aims of this study were to determine the HR response of referees during men's Eurobasket	HR, BC.		The heart rate was directly associated with REF's anthropometric features and years of experience. However, it did not show any association with different game variables such	93.3

					Championship and identify relationships between body composition and other match variables as predictor of HR		as: total scores, differences of scores among teams, duration of the game or ratio time/point ratio. The study also showed that variables of triceps skinfold (β : 1.33; $P<0.00$), years of experience (β : -0.40; $P<0.05$) and fat mass (β : -2.51; $P<0.00$) were the variables that significantly predicted the physical performance.	
	Allegretti et al., 2015.	6M	6		The aim of the study was to describe the distance covered per quarter, during official games, by elite basketball referees, using a computer aided video-based tracking system.	Distance covered	The referees covered on average 1130.03 m (± 160.72 m) per quarter game. Most of the time they remained standing or with small lateral movements, corresponding to 87.1% of the total game duration.	80.0
	Bayón et al., 2015.	Experimental and Control	24		To ascertain the difference between groups after a training program.	RSA, Height, Weight, % fat, BMI.	The improvements in the RSA of basketball referees will clearly enhance their fitness as well as their kinanthropometric values. Both groups improved after the training program.	86.7
	Matkovic et al., 2014.	31 National	31	1 Season	The objective of this study was to establish physiological loads elite basketball referees sustain during competitive games	Age, HR, HR zones	There were no significant differences between younger and older referees in the physiological load they sustain during the games. The average HR during a game was 131.52 ± 9.10 bpm, that is, $77.34 \pm 6.05\%$ of the HR at the anaerobic threshold. It was established that the referees spent 50% of the total game time in zones of high aerobic load (extensive and intensive aerobic zone), whereas if only the time during the quarters is examined, then this percentage amounts to 60%. The referees spent only 1-2% of the total game time in the anaerobic energy process load zone.	93.3
	Vaquera et al., 2014.	26 International	26	48 games	The purpose of the study was to describe heart rate responses of referees	HR, %HRmax, HR zones	The data suggest that international basketball referees are unable to maintain initial exercise intensity for four successive quarters of	86.7

					during a major international basketball championship		championship play. This is in contrast to available data suggesting elite players are able to maintain or increase exercise intensity as games progress.	
Bonganha et al., 2013.	17 International 20 National	37			To characterize the metabolic and neuromuscular performance and body composition of Brazilian elite referees.	Body Composition, Neuromuscular variables, metabolic parameters and referee level.	There were no significant differences in any of the variables according to referee's level. Compared to the players the referees' results were lower in metabolic and neuromuscular variables and higher in body composition.	80.0
Borin et al., 2013	16 International 2 National	18			To measure and evaluate the distance covered by referees in a game by measuring the number of interruptions, %HR, and [lac] in different phases of competition and in different MPs.	HR, Distance covered, Blood Lactate, Competition.	Regarding the distances covered, we observed significant differences (P<0.05) in the 1st, 2nd, and 3rd MPs between the FP and the other two phases (SP and QP) throughout the game, between each phase; in the 4th MP, a significant difference was found when comparing the QP and the other two phases. Comparing the periods within each phase, we found that a greater distance was covered in the 4th MP in relation to the 3rd MP during the FP. No significant differences were found among the remaining variables.	86.7
Rupcic et al., 2012.	31 National	31	1 season		The main object of this research was to determine the existence of statistically significant differences in the physiological load of referees considering the period of the basketball game	Average heart rate; maximum heart rate, energy consumption (kcal/min).	Given the obtained results of univariate variance analysis it was concluded that there are no statistically significant differences in the physiological load between the first and second half – time, or between particular quarters of basketball games.	71.4
Rupcic et al., 2011	31 National	31	1 Season		The purpose of determining differences in anthropological profile of basketball referees	BC, Quality and Experience	According to our results basketball referees differ only in the variables for the assessment of motor abilities, while there were no statistically significant differences in the tested	85.7

according to their
chronological age.

morphological characteristics and functional abilities regarding referees' ages. To conclude, investigated basketball referees were all physically well prepared, meeting the high standards of physical conditioning-motor preparation needed for the basketball games at the highest national level.

Leicht, 2008.	7 International	6M 1F	7 referees	8 games	The aim of this study was to examine the physiological demands of basketball refereeing during international competition.	HR (bpm), %HRmax, %Time to HR	There were no significant differences between quarters for any variable. Referees, using a two-referee per game format, worked at an average HR of 150 bpm (range 110—181 bpm) for each quarter of the game, equalling a relative intensity of >70% HRmax for most (~76%) of each quarter.	80.0
Leicht, 2007.	25 National	25M	25		The aim of the study was to document the aerobic power and BC of elite basketball referees.	BC, Aerobic Power	Elite basketball referees demonstrated significantly greater aerobic power and similar body composition to the general community. In the euhydrated state, adult provided valid measurements of body fat% in elite basketball referees.	71.4
Leicht, 2004.	1 National	1M	1		This case study examined the cardiovascular stress experienced by an elite basketball referee during national competition games	Age, BC, HR (Cardiovascular stress)	The average heart rate was similar for all games (73%) of HRmax and was experienced for most (>63%) of the game. Similar relative exercise intensity was demonstrated regardless of game play (men vs. women) and officiating type (two or three referees). Further study is needed to document the physiological characteristics of elite basketball referees for better performance	64.2

Note: *QS=Quality Score; M=Male; F=Female; UWB=Ultra-Wide Band; PL=PlayerLoad; METs=Metabolic Equivalents; HR=Heart Rate; HRmax; Maximum Heart Rate VO₂max=maximum rate of oxygen consumption; BC=Body Composition; RPE=Rating Perceived Effort; EE=Energy Expenditure; [lac]=Blood Lactate Concentration; RSA=Repeat Sprint Ability; HIA=High Intensive Accion; MP=Match Period; FP=Final; SP=Semifinal; QP=Qualifying; bpm=beats per minute.*

Table 4. Psychological Demands Studies.

Authors & Year	Sample				Aim	Variables	Main Results	QS (%)
	Level	Gender	Nº subjects	Nº games/cases				
Arbinaga et al., 2019	30 National 124 Referees in training		154 referees		1- To determine the existence of differences in the scores when assessing burnout in soccer compared to basketball referees and 2.- To analyse if the scores on the resilience scale can act as a protective factor against burnout syndrome.	Social (Sex, Year of birth, Civil status) Sports (Type of sport, experience, Training, Injuries, Burnout, Resilience	Soccer compared with basketball referees show greater emotional exhaustion, depersonalization and personal fulfilment. Those who obtain high scores in resilience (29.8%), compared to those who obtain low scores (70.2%), show less emotional and personal realization; but do not show differences in depersonalization ($p = .561$). Soccer referees present a greater risk of obtaining scores that indicate low resilience compared to basketball referees.	93.3
De Almeida et al., 2018.	236 Regional 111 National 44 International	263M 128F	308 referees 83 officials		The aim of this study was to verify the psychometric properties of the BRUMS mood scale for basketball referees, with performance inside court or as table officials, through Exploratory Factor Analysis (EFA).	BRUMS scale	The results indicated that the BRUMS-AB scale has good psychometric properties that give it evidence of validity and reliability for its use in the context of basketball refereeing.	93.3
García- Santos et al., 2017.	6 referees in training	4M 2F	6		To ascertain the differences in the stress variable according to the gender of the referee.	LISEA questionnaire.	In all cases women are more affected than men both before and after the game. As is shown, women are more influenced by the name of the coach, the players, the ranking of the team in competition, the refereeing companions, the venue, the court where they referee and the presence or not of a game delegate.	80.0
Ritchie et al., 2016.	108 Referees in training	102M 6F	108	9 cases	The present study examined the effect of situation criticality on stress levels experienced by officials.	Stress Appraisal Measure (SAM).	Results revealed that situation criticality has an effect on officials' perceived stress levels. Both threat and challenge appraisals were positively correlated with perceived stress. Overall, these findings indicate that officials'	92.9

							stress levels fluctuate within games depending on score differential and time of game. The findings encourage officials to recognize and manage their stress, possibly through their appraisals.	
Anshel et al., 2014.	64 Regional 61 Referees in training	108M 17F	125		The purpose of this study was to externally validate and test a conceptual transient model involving six paths that linked sources of acute stress to avoidance and approach coping styles among Turkish basketball referees.	Basketball Officials Stress Inventory (BOSI)	Results indicated that the model achieved a good fit and that all paths tested simultaneously were significant. The distractions stressor was positively related to subpar performance, which, in turn, was positively related to verbal abuse. Verbal abuse was negatively associated with an avoidance-cognitive coping style and positively related to the approach-cognitive coping style. The results also supported a crossover effect of both avoidance-cognitive and approach-cognitive on approach-behavior.	93.3
Anshel et al., 2013.	Referees in training	M	1496		The purpose of this study was to develop and calibrate the Sources of Acute Stress Scale for Sports Officials (SASS-SO) using the Rasch model.	SASS-SO	Using the Rasch model, the level of sources of stress item, difficulty and individual's level of acute stress were estimated. Infit and Outfit measures were within the appropriate range supported by the unidimensional structure of the SASS-SO. The two most severe sources of acute stress were "I made an incorrect call" and "I was out of position." The two least severe sources of acute stress items were "I received verbal abuse from players" and "My supervisor/evaluator was present."	100
Jaenes et al., 2012.	59 National	57M 2F	59	15 cases	The objective of this study was to draw up a list of stress related situations both before and during the game.	Stress Situations. LISEA	The survey showed a very high accuracy value (.897) Results show that different stress sources have a varying influence depending on the moment in the competition, except for one item.	78.5

Stewart et al., 2004.	324 Training	312M 12F	324	The purpose of this study was to survey certified high school basketball officials during midseason to assess whether the sources and magnitude of perceived psychological stress would be consistent with previous studies of officials in other sports.	Adaptation OSOS, Likert scale 0-3.	The highly rated stressors among the various factors were "players and coaches protesting decisions" and "having a bad game." These scores can be interpreted as approaching "moderate" stress. Stressors near the middle of "mild" to "moderate" stress were "having an aggressive game" and "making a bad call." In terms of percentage of officials responding "Strongly" to specific questions, "Dealing with players or coaches who protest a decision" was 24.0%, "Having a bad game" was 21.2%, "Dealing with over-excited or hostile coaches" was 19.0%, "Making a bad call" was 16.7%, and "Dealing with an aggressive game" was 16.7 % .	73.3
Kaissidis-Rodafinos & Anshel, 2000.	162 National		162	The authors examined the effects of situational appraisals (perceived control and intensity), coping styles (monitoring and blunting), and personal dispositions (optimism and self-esteem) on the approach and avoidance coping responses	These instruments measured self-reports of monitoring and blunting coping styles; optimism; self-esteem; and perceived stress, perceived control, and the consistency of approach and avoidance coping responses	The results were equivocal: The Greek referees were not consistent in using avoidance and approach coping responses across situations. Approach coping was more predictable than avoidance coping in accounting for both situational and personal variables.	64.3
Kaissidis-Rodafinos et al., 1998.	113 National		113	Referees were analyzed to compare the perceived intensity of stress and their responses during IT acute stressful situations.	Stressful Situations.	Australian referees considered the stressors, "Arguing With Players", "Arguing With Coaches", "Making a Controversial Call", "Verbal Abuse From Coaches", "Verbal Abuse From Players" and "Making a Controversial Call" to be significantly more stressful than their Greek counterparts. On the other hand, Greek referees, as compared to	71.4

Kaissidis-Rodafinos et al., 1997.	133 National		133			The aim of this study was to establish the ways in which coping style and situational appraisals are related to the consistency of using approach and avoidance coping strategies	Coping Style, Coping Strategies and perceived stress.	Australians perceived "Presence of Media" to be more stressful. Qualitative data revealed differences in the referees' perceived intensity of stress as well as in their thoughts and coping responses to these sources of stress. Findings indicated that: referees exhibited consistent avoidance, but not approach, coping styles; they used more avoidance than approach strategies; and they perceived stress to be positively correlated with approach, and negatively associated with avoidance, coping strategies. These findings suggest that individual differences exist in perceptions of stress (i.e. situational appraisals), controllability and coping styles among moderately and highly skilled basketball referees.	80.0
Anshel, 1995.	20 Experts		20			The purpose of this article is to describe the construction (Phase 1) and external validation (Phase 2) of a behaviorally anchored rating scale (BARS) for identifying and measuring competencies for basketball referees (BARS-BR)	BARS-BR.	The results lent support to the validation of the BARS-BR for assessing competence in basketball officiating.	71.4
Anshel & Weinberg 1995.	132 National	132M	132	15 cases		To compare the perceived sources of stress for American and Australian basketball officials.	The BOSSI consists of 15 items (stressors) from which subjects circle a number from 1 (not at all) to 10 (extremely).	The overall ranking of the sources of acute stress from the BOSSI indicated that making a wrong call, verbal abuse by coaches, threats of physical abuse, being in the wrong location when making a call, and experiencing injury were the top five sources of stress.	71.4
Rainey & Winterich, 1995.		667M 56F	723	15 cases		To ascertain the degree of stress of the basketball referee using a questionnaire	3-item-scale	The basketball referees responded to a survey that assessed stress related to officiating. Mean reported ratings were between "very little" and "moderate amount"; only 4% reported high stress. Results are consistent with other	57.1

Kaissidis- 38 National
Rodafinos 26 Training
& Anshel,
1993.

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The purposes of this study were to: (1) identify the sources of acute stress that affect basketball referees, and (2) compare the degree of perceived acute stress between adolescent and adult Australian basketball referees.

The referees rated the intensity of 15 sources of acute stress they commonly experience during the game

accounts, suggesting that most sport officials experience low occupational stress. A MANOVA revealed that young referees were significantly more stressed than their adult colleagues about 'making a wrong call' and 'giving a technical foul.' Stressors ranked highest were 'threats of physical abuse', 'verbal abuse from coaches,' and 'making a wrong call.' Sources of stress ranked lowest included 'presence of media', 'making a mistake in mechanics' and 'verbal abuse by spectators'.

64.3

Note: *QS=Quality Score; M=Male; F=Female; HG=High Level; MG=Medium Level; LG=Low Level*

Table 5. Multifactorial Analysis

Type	L	S-E		Ref Skills		Comp Variables		Team Charact		Players Characts		Game Know		Success Decision		BC		HR		Dis Covered		Met Energy		Lac		Neuro Variables		Stress		
		Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	
Decision-Making (16)	Int		5		5		2		3		2		3		5		1		4		5		5		5		5		5	
	Nat	1	1	1	1		2			1	1	1	1	2			2	2	2	2	2	2	2	2	2	2	2	2	2	
	Reg		3		3		1		2		1		2		3		3	3	3	3	3	3	3	3	3	3	1	2		
	Train		1		1		1			1			1		1		1	1	1	1	1	1	1	1	1	1	1	0		
	Exp	1	1		2		1		1		1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	
	Mix	1			1			1			1			1	1		1	1	1	1	1	1	1	1	1	1	1	0		
Physical/Physiological Demands (20)	Int		9		9		4		5		9			9		9	4	5	7	2	3	6	2	7	1	8	1	8		9
	Nat		8		8		6		2		7			7		7	6	2	5	3	1	7	4	4	1	7	1	7		8
	Mix		3		3		2		1			3			3		3		1	2	2	1	1	2	1	2	1	2		3
Psychological Demands (15)	Nat		5		5		1		4		5			5	5		5	5	5	5	5	5	5	5	5	5	5	5		
	Train		3		3		2		1		1	2	1	2	3	2	1	3	3	3	3	3	3	3	3	3	3	3		
	Exp		1		1				1				1		1		1	1	1	1	1	1	1	1	1	1	1		1	
	Mix	1	3		4		2		2		2	2	2	4	2	2		4	4	4	4	4	4	4	4	4	4	4		
Review (1)	Mix		1		1		1			1			1		1		1	1	1	1	1	1	1	1	1	1	1		1	

Note: *L=Level; Int=International; Nat=National; Reg=Regional; Train=Training; Exp=Experts; Mix=Mixed; Y=Yes; N=No; S-E=Self-Efficacy; Ref Skills=Referee Skills; Comp Variables=Competition Variables; Team/Players Charact= Team/Players Characteristics; BC=Body Composition; HR=Heart Rate; Dis Covered=Distance Covered; Met Energy=Metabolic Energy; Lac=Blood Lactate; Neuro Variables=Neuromuscular Variables; Stress=Stressful Situations.*



Figure 1. *Diagram of Search Process*

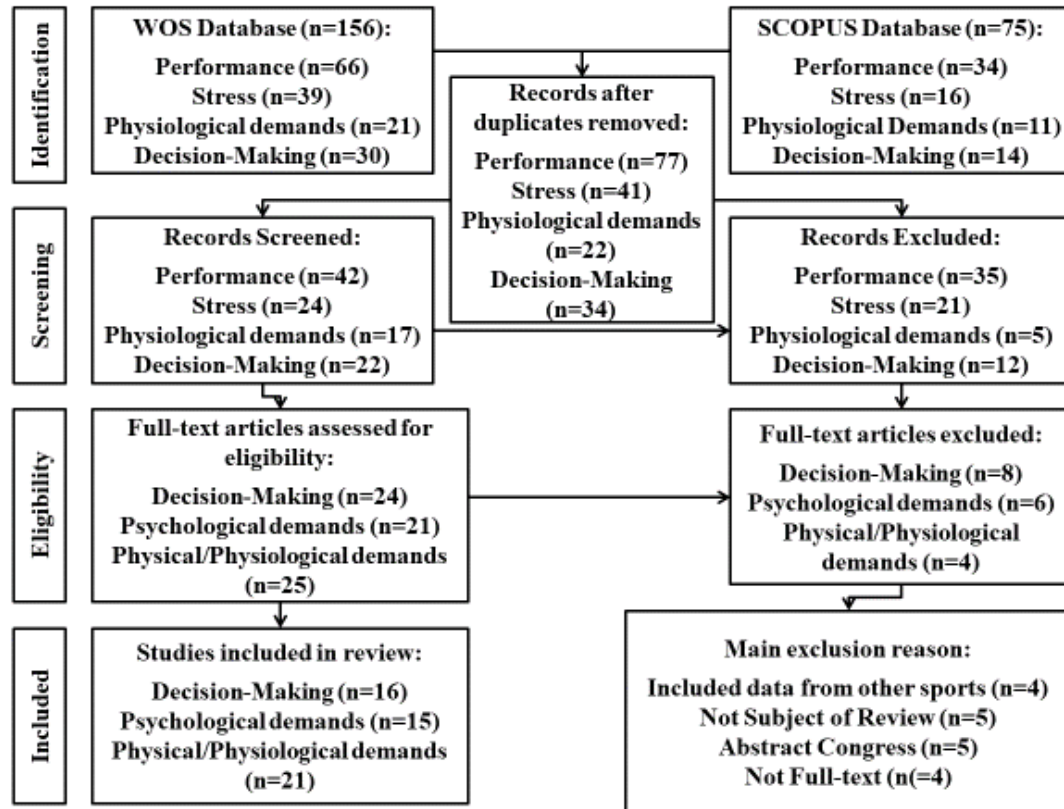


Figure 2. *Flow chart of the procedures used for the article search.*

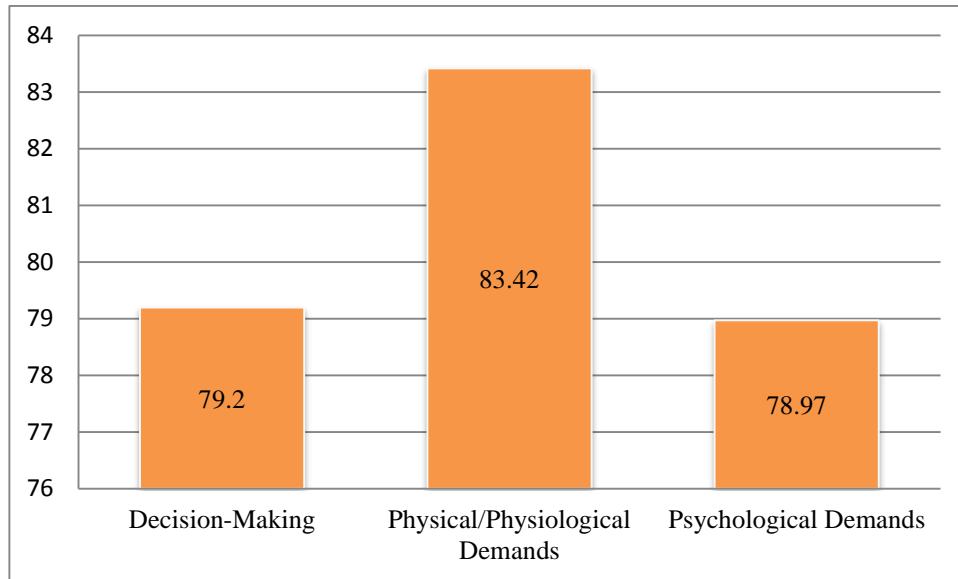


Figure 3. *Methodological Quality*



Figure 4. *Decision Making Profile*

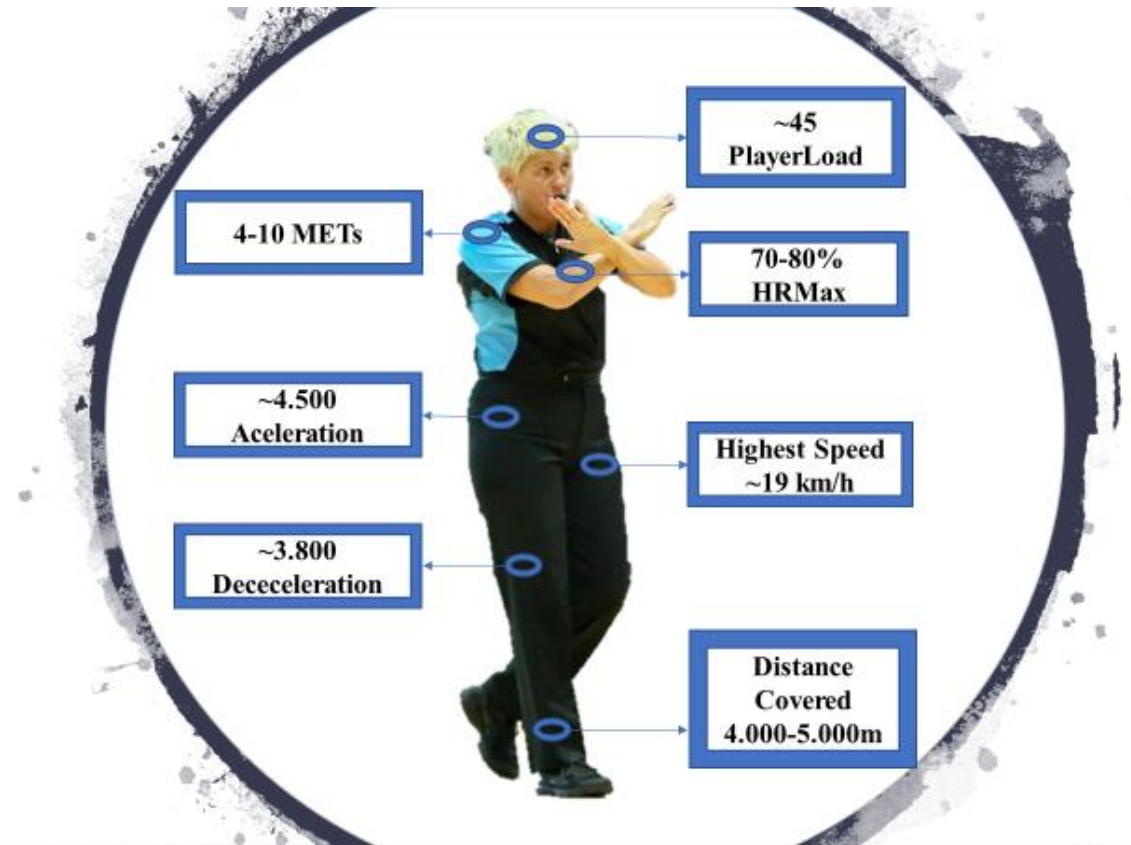


Figure 5. *Basketball Referee Physiological and Physical Responses during Game*

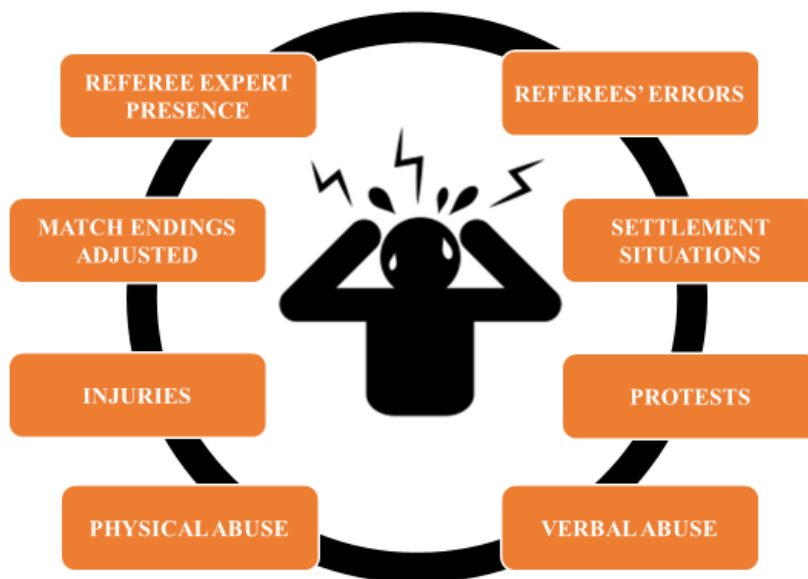


Figure 6. *Referee Stressful Situations*

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2 **SYSTEMATIC REVIEW OF BASKETBALL REFEREES' PERFORMANCES**

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1 ABSTRACT

2 The importance of umpire during competition makes it essential to identify in
3 detail the referee's performance. The present study aimed to carry out a bibliographic
4 review that presents an analysis of the factors that influence a referee's performance, from
5 the physical/physiological, psychological and decisional points of view. The design was
6 centered on a systematic data review according to Preferred Reporting Items for
7 Systematic Reviews and Meta-Analyses (PRISMA). The data bases used for the review
8 have been WOS and SCOPUS. The inclusion criteria were: (i) Studies in English and
9 Spanish; (ii) Investigations on the physiological, psychological and technical profile of
10 basketball referees; and (iii) Relevant data on the performance of basketball referees
11 during competition. After the review process 51 articles were selected, classified into
12 three groups of variables: "Decision-Making" (16), "Psychological Demands" (15) and
13 "Physiological/Physical Demands" (21). The results show the importance and influence
14 of the basketball referee during competition and the need to work on their continuous
15 training according to the requirements of the game. Specifically, the referee must work to
16 improve in three principal aspects: decision-making (knowledge of the rules, their
17 application during the competition, the mechanics of movements or the control of the
18 game in situations of conflict or stress); physical/physiological condition (HR, Distance
19 Covered, Speed, PlayerLoad or METs) and stress situations (referee errors, protests,
20 abuses or game adjusted). All of the above, should be related with the experience and
21 competence that all referees should acquire to be able to develop their functions as
22 successfully as possible, using the different tools and methods detailed in the studies
23 analyzed to help them to improve their vision and their role in competition.

Keywords: Basketball Refereeing, Decision-Making Profile, Physiological Profile and Psychological Profile.

1. INTRODUCTION

In the sports context, the role of the referee is gaining increasing importance in the development of competition (Louvet et al., 2009), as without his or her presence it is currently complicated to enforce the rules of each sport. Each sports discipline presents different characteristics in its rules, but all of them are focused on facilitating the development of the game and sanctioning the infractions that hinder its correct evolution. Due to the evolution of sport (Allegretti et al., 2015; Ibáñez et al., 2018) and professionalization of their role, referees need a series of skills, knowledge and attitudes that enable them to carry out their functions accurately and correctly (García-Santos & Ibáñez, 2016), and even more so, if they are the center of attention (of players, coaches and spectators) in the conflictive situations that arise in every game in the different competitions (Pedrosa & García-Cueto, 2015; Karacam & Adiguzel, 2019). Therefore, referees need continually to have better training from the physiological, psychological and technical-tactical points of view (García-Santos et al., 2017), that permits them to improve their experience, self-efficacy (Myers et al., 2012) and refereeing judgement (Dosseville et al., 2011; Pizzera & Raab, 2012).

In basketball, as in other sports, the referees have to make decisions within milliseconds, so that it is important for them to work and prepare themselves to face this type of situations, to achieve an adequate performance during the competition that makes it possible for them to be more competent in their functions (Guillén & Feltz, 2011). Different variables influence the decision-making (Ahmed et al., 2017) and performance of the referee (García-Santos et al., 2017), as well as tools that make it possible to quantify

1 them. The most commonly studied variables in referees have focused on analyzing
2 physiological demands, like heart rate (HR) (Leicht, 2008; Matković, et al., 2014;
3 Vaquera et al., 2017), kinematic variables like distance covered, speed, etc. (Allegretti et
4 al., 2015; Borin et al., 2013; Nabli et al., 2017; García-Santos et al., 2019), or
5 neuromuscular variables (Bonganha et al., 2013; García-Santos et al., 2019; Leicht et al.,
6 2019). Similarly, there are studies centered on analyzing the psychological demands and
7 stressful situations during competition (Cantón et al., 2011; Ramírez et al., 2006; Slack
8 et al., 2013; Anshel et al., 2014). Lastly, there are studies that analyze the situational and
9 technical variables of refereeing itself (García-Santos & Ibáñez, 2016; García-Santos et
10 al., 2017), as it is essential to understand the way that the rules have to be enforced.

11 Several tools or methods are available to analyze and quantify these variables.
12 Regarding the physiological aspect, HR monitors have commonly been used, as well as
13 the subjective rating of perceived exertion (RPE) using Borg's CR-10 scale (Borg, 1982),
14 due to their low cost and easy handling. Currently other methods are being used to assess
15 the physical performance of referees more precisely like video-based-training (VBT)
16 (Allegretti et al., 2015; Nabli et al., 2017), global positioning system (GPS) (García-
17 Santos et al., 2017) or inertial devices with Ultra-WideBand (UWB) technology that
18 permit measurement of indoor sports (García-Santos et al., 2019). In the psychological
19 context there are questionnaires focused on determining efficacy, stress, anxiety, etc., like
20 the LISEA questionnaire (Jaenes et al., 2012), which is specifically for basketball
21 referees. It is also important to analyze the technical and mechanical part of the referee's
22 movement, for which there are instruments like the IOVAB (Observational Instrument to
23 Basketball Referee Evaluation) (García-Santos & Ibáñez, 2016), that assesses the
24 performance of the referee during the competition.

Given this scientific panorama, there is a need to collect together the different studies and carry out a more detailed analysis of the performance of basketball referees, therefore the aim of the present systematic review was to analyze the existing literature on basketball referees' performances according to the physiological, psychological and decision-making demands of competition. In order to establish adequate training program for the needs of the referees and competition.

2. METHODS

2.1 Design

The present study is a review of the literature on basketball referees, using a systematic retrieval of data and study selection processes (Ato et al., 2013). The aim was to analyze and learn about existing research centered on the study object.

2.2 Search Strategy

The success of a good literature review lies in adequate planning (Thomas et al., 2015). Establishing the strategies and steps to be followed makes it possible to draw relevant conclusions. The literature search process used in the present study is shown in Figure 1.

*****Figure 1 near here*****

The electronic bibliographic search was carried out during the month of October 2019, collecting all the articles found up to that date in the Web of Science (WOS) and Scopus databases. The keywords used for the search were "Basketball Referee", associated in each case with the following words: "Performance", "Stress", "Decision-making" and "Physiological Demands". The search was made both in Spanish and English.

The systematic literature review followed the proposal of Sarmento et al., (2018), according to the guidelines determined by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (Moher et al., 2009; 2015), where the review selection process was divided into four phases: a) Identification, b) Screening, c) Eligibility and d) Inclusion (Figure 2).

Figure 2 near here

2.3 Inclusion and Exclusion Criteria

The inclusion criteria used for the articles were: (i) Studies in English and Spanish language; (ii) Research on the physiological, psychological and technical profile of basketball referees; and (iii) Performance data of basketball referees during competition.

The exclusion criteria were: (i) Articles about referees from other sports; (ii) Research carried out outside of the competitive framework; (iii) Variables that did not coincide with the review topic; and (iv) Abstracts from congress presentations.

2.4 Variables

The articles that fulfilled the inclusion criteria were classified into three main groups of variables: “Decision-making”, “Physiological/Physical Demands” and “Psychological Demands”. This classification was made after analyzing the variables present in the retrieved texts, as there could have been duplicates in the search according to the keywords or articles which once read did not coincide with the keywords. The following variables were detailed for each study: author/s & year, sample (level, gender, number of subjects and number of games or cases), aim, variables, main results and quality score.

2.5 Data Extraction and Quality

A table drawn up by Law et al. (1998), was used to assess the quality of the studies. It is composed of 16 items that measure the quality of the methodology (Table 1). The score for each item follows a binary scale (0/1) where 0 is for a negative answer and 1 for an affirmative answer. There are two items (6 and 13) which were not applicable to all the studies, and therefore the option NA (not applicable) was included. The sum of all the positive items from the total number of items was used to indicate the quality of the study. According to the score, the articles were classified as of low methodological quality (<50%), good methodological quality (51-75%) and excellent methodological quality (>75%) (Sarmiento et al., 2018).

Table 1 near here

2.6 Reliability

Two reviewers who had experience in the analysis of document reliability calculated the reliability of the data according to the Quality Score (QS). To achieve an adequate reliability of the data it is necessary to carry out a reliability analysis of at least 10% of the study sample, and in this case a total of 5 articles was analyzed. The inter-rater analysis was performed with Cohen's Kappa (Randolph, 2005), obtaining a value of .891. This is defined as "almost perfect" reliability as indicated by Landis and Kolch (1977), as it is between the values of 0.81-1. These authors establish different categories: <0.00 (Poor); 0.00-0.20 (Slight); 0.21-0.40 (Fair); 0.41-0.60 (Moderate); 0.61-0.80 (Substantial) and 0.81-1 (Almost Perfect).

2.7 Data Analysis

Initially a descriptive analysis was performed on the selected studies detailing the type of sample (level, sex, number of subjects and number of games or cases), the object

of study, the studied variables, the main results and the quality of the study (see Tables 2, 3 and 4). Subsequently, an analysis of the contingency tables was carried out to observe the relations among the type of study, level and different variables related to the three main groups established (see Table 5).

3. RESULTS AND DISCUSSION

The aim of the present study was to draw up a systematic review on the performance of basketball referees. For systematic reviews it is important to select suitable keywords, and to develop a methodological process which is adequate for the characteristics of the study. (Ato et al., 2013). The results show that basketball refereeing has been analyzed from several viewpoints: technical demands using decision-making, physiological demands related to internal and external load, and psychological demands, especially focused on different stressful situations.

3.1 Search, Selection and Inclusion of Publications

A total of 231 articles was identified in the WOS and SCOPUS data bases which were divided into three large groups of variables. Some of the references were duplicates and were eliminated, leaving 174 investigations. After reading the abstracts only 105 articles remained of which 70 were examined in detail: Decision-making=24, Physiological/Physical demands=25 and Psychological demands=21. After an in-depth reading of the different articles a total of 52 documents remained in the final review: 16 on decision-making, 15 on psychological variables and 21 on physical/physiological load variables (Figure 2). The main exclusion factors of the studies were that they were congress presentations (n=5) or the topic of the research did not coincide with the subject of study (n=5).

3.2 Quality of the Studies

After analyzing the inclusion and exclusion criteria of the different studies in the present review, the selected articles are described in detail according to the study variables. The studies presented a high methodological quality (Figure 3), with the highest percentages corresponding to the studies related to the variables of physiological/physical load (83.42%), followed by those on decision-making (79.20%), and lastly those referring to psychological demands (78.97%).

Figure 3 near here

3.3 Decision-Making

Regarding referees' decision-making a total of 16 articles was analyzed in depth showing excellent methodological quality (79.20%) (Table 2). Decision-making is of extreme importance for a basketball referee's performance, as there are a multitude of situations or moves that need to be assessed and that influence the development of a game. According to the different studies found, there are tools which make it possible to evaluate referees' technical performance or improve their decision-making, like the IOVAB (García-Santos & Ibáñez, 2016); the BOFQ questionnaire (*Basketball Officials' Favoritism Questionnaire*) (Gencay et al., 2015); the FOLQ questionnaire (*Functions of Observational Learning Questionnaire*) (Hancock et al., 2011) and the BBFBR program (*Basketball Board for Basketball Referees*) (Markoski et al., 2011). The most important aspects of each one is described below. The IOVAB tool analyzes the movements that the referee makes during the competition according to the refereeing mechanics, violations, fouls, collaboration with companions and control of the game. The use of this instrument requires the evaluation on the part of experts or technical referees visualizing the match in real time or from a recording to obtain a precise and detailed value judgement. It is also possible for the referees themselves to carry out a self-evaluation at

1 the end of the match, to ascertain their own perception of their performance and compare
2 it with the evaluation of the technical referee.

3 The BOFQ questionnaire expresses the influence or the degree of favoritism that
4 the referees present in their decisions depending on the team, players or coaches. It also
5 observes the pressure that the public can exert on their decisions during the game.

6 The FOLQ questionnaire evaluates through different questions what variable is
7 the most important for a basketball referee. The variables presented are: technical skill,
8 strategy or reading of the game and the performance (correct or incorrect decisions) in
9 the different game situations. The results are also compared with the players and coaches.

10 Lastly, the BBFBR program presents a series of real game situations using a video
11 which makes it possible to train referees' in decision-making. It is a viable tool to place
12 the referees in different situations which they will later have to solve on-site during
13 games.

14 There are also studies that analyze the degree of influence of the players, coaches,
15 teams or spectators in referees' decision-making, according to the anthropometric
16 characteristics of the players, their reputation and that of their teams, the position that the
17 team occupies in the ranking or whether they are playing at home or away or the pressure
18 that the stands can apply on the refereeing staff (Morgulev et al., 2018; Gencay et al.,
19 2015; Gift & Rodenberg, 2014; Anderson & Pierce, 2009). Similarly, the referees have
20 to be able to live with their mistakes (McMahon & Mildenhall, 2012) and recognize their
21 limitations, developing selective attention (Hack et al., 2009) which permits them to tune
22 out situations that are unrelated to the game and improve their efficacy in the competition
23 (Karacam & Agudizel, 2019). Another aspect to highlight in decision-making is the level
24 of refereeing competence or category and sex, which are better when the referees are more

experienced (Gencay et al., 2015), while sex does not influence decision-making (García-Santos et al., 2017). These results determine the importance of training and improving decision-making using different tools that help to reduce the error rate and make it possible to adapt to the different situations that competition provides with the best possible chances for success, **developing a good refereeing self-efficacy (Myers et al., 2012) and a positive perception by the players, coaches and spectators.** Therefore, an analysis of referees' decision-making is very important for their progress and efficacy (García-Santos & Ibáñez, 2016). To this end, **it is possible to determine different training programs that improve the referee's decision making, such as reviewing game conflictive situations and their possible solutions or proposing real situations where the referee have to make the best possible decision with a limited time.** Figure 4 shows the most important aspects to take into account for a correct referee decision-making, **according to the different studies (n=16) included in this review, that were conducted on the decision making of basketball referee.**

*****Figure 4 near here*****

*****Table 2 near here*****

3.4 Physiological/Physical Demands

Table 3 shows the results regarding the variable “Physiological/Physical Demands”, showing that after the methodological processes were performed a total of 21 articles were reviewed with a quality score of 83.42%. This group includes the variables of physiological and physical loads. The method for measuring physiological load most commonly used, due to its ease of use and low cost, is HR. **According to different studies (Nabli et al., 2019), basketball referees during the game usually have HR values between 70-80% of their HRmax.** This variable has been related in several studies with body

composition (Vaquera et al., 2017; Vaquera et al., 2016; Leicht, 2002), where it is not shown that an improvement in HR produces an improvement in anthropometric values. Similarly, HR has been studied according to the gender of the referees, showing that the men referees record higher values (Vaquera et al., 2016) or according to age (Matkovic et al., 2014), where there were no significant differences among the referees. HR variability has also been studied during different periods of the game, and were found to be similar during the whole game (Nabli et al., 2016; Rupcic et al., 2012; Leicht, 2008). It is even possible know the difference depending on the level or category of the game, where it exists higher values in international categories (Leicht, 2004; 2008; Nabli et al., 2019) or if it is a championships, it is possible to observe differences between the first phases of the tournament and the final phases where the title is being played. In this case, the title games present higher values (Borin et al., 2013; Nabli et al., 2019). Similarly, the refereeing system (2 or 3 referees per game) can influence HR values, being higher in those competitions or games where it is refereed with two referees (Nabli et al., 2019). Therefore, these results show that HR does not determine the referee's performance, as it is usually constant during the game, but it is advisable to monitor the referee's HR to confirm that it is within normal values and the referee is not suffering from some type of anomaly.

There are other studies that have analyzed other types of physiological load, like the blood lactate concentration (Nabli et al., 2016; Nabli et al., 2016; Borin et al., 2013) or the RPE (Vaquera et al., 2017), neither of which showed significant values during the different quarters of a game. Although neither of the two variables showed significant values with regard to performance, it is advisable to use the RPE rather than the analysis of lactate in the blood, as it is a non-invasive and cheaper.

Regarding the physical load, studies have been found on time-motion analysis during the game and the distance covered by a basketball referees is around 1,200 meters per quarter (Allegretti et al., 2015; Borin et al., 2013; García-Santos et al., 2019; Nabli et al., 2016), where 60-70% walking, about 2% sprinting and the rest jogging or running. It is also worthy of note that 87% of the time they are making short lateral movements. Specifically, the highest maximal speed reached by the referee was around 19km/h during transitions or sprint actions (García-Santos et al., 2019). Likewise, a basketball referee usually performs around 4,500 accelerations and 3,800 decelerations per game (García-Santos et al., 2019b). So that for referees to improve their physical fitness they should train according to the characteristics of the competition, thus it is possible to state that training repeat sprint ability (RSA) enhances the referees' fitness (Bayón et al., 2015). It is also necessary to understand the referee's energy expenditure during the game, which in the case of the basketball referee is predominantly from aerobic metabolism (Nabli et al., 2017) with a workload around 44PL (García-Santos et al., 2019), and always below the workload reached by the players (Leicht et al., 2019). Thus, for referees to improve their physical/physiological profile they should focus on their own physical and physiological condition and carry out fitness programs adapted to the needs of the competition, where game conditions are reproduced. According to the researchers analysed, the figure 5 summarises the basketball referee's physical/physiological fitness profile, highlighting the main factors could affect of each game (the HR, the time motion analysis and the workload profile).

Figure 5 near here

Table 3 near here

3.5 Psychological Demands - Stress

Table 4 presents the studies that analyzed psychological variables. A total of 15 investigations were identified with excellent methodological quality (78.97%) (Sarmiento et al., 2018), focused basically on the variables associated with stress. Some of the studies created tools that measure stress (De Almeida et al., 2018; Anshel 1995; Stewart et al., 2004; Jaenes et al., 2012; Anshel et al., 2013; Anshel et al., 2014), others observed stress using these tools in competitive situations (García-Santos et al., 2017; Ritchie et al., 2016) or with the visualization of different stressful moves using a monitor (Anshel & Weinberg, 1995; Kaissidis-Rodafinos et al., 1997; 1998; Kaissidis-Rodafinos & Anshel, 2000). Moreover, these studies analyze the differences among referees, with regard to gender, with women being more affected (García-Santos et al., 2017), to the referee's level, with the novice referees recording the most stress (Kaissidis-Rodafinos & Anshel, 1993; Anshel & Weinberg, 1995; Ritchie et al., 2016) or the referee's nationality: Turkish (Anshel et al., 2014), Greek (Kaissidis-Rodafinos & Anshel, 2000), American and Australian (Anshel & Weinberg, 1995) and Greek and Australian (Kaissidis-Rodafinos et al., 1998). **The most stressful situations for the referees in these studies were: when the referee instructor was present at the game, when there were mistakes in the officiating mechanics, when a foul has been erroneously called, when there was an injury, when there were protests by the players or coaches, and lastly, when the instant replay was used.** So, it is necessary to work on all these types of situations to be able to reduce the stressful events in competition. As stated by Rainey & Winterich (1995) and Stewart et al., (2004) about 5% of the situations that arise in a game cause high values of stress, while the normal development of a game presents low or medium values. It is possible to attribute these high values of stress to important situations during the competition which may decide the result of the game, like for example the moves analyzed on instant replay, or

1 protests like physical or verbal abuse that lead to players or coaches being disqualified or
2 sanctioned with technical fouls. Therefore, working on this type of situation will make it
3 possible to reduce the referees' stress rates and help them to learn to live with their
4 decision-making mistakes or conflict situations. The figure 6 figures out the stressful
5 situations that the referees have to deal with during a game.

6 *****Figure 6 near here*****

7 *****Table 4 near here*****

8 **3.6 Multidimensional Analysis**

9 After the analysis of each of the selected studies, Table 5 presents the relations
10 that exist among the type of study (*decision-making, physical/physiological demands and*
11 *psychological demands*), the level of the referee (*international, national, regional,*
12 *training, experts and mixed*) and the different variables found in each of the studies.
13 Within the decision-making group it can be seen that the most influential variables are
14 those related with the success of the decisions made, the technical skills of the referee,
15 the variables associated with the competition (result, score, end of game...), the
16 characteristics of the players (large players, skilled players, the best player in the team...)
17 and the teams (local, visitor, position in the competition ranking...) (Morgulev et al.,
18 2018; Gift & Rodenberg, 2014) and of course the knowledge the referee has of the game.
19 All these variables influence to a greater or lesser extent the decision-making of the
20 referees, independently of their level (international, national, regional, training or
21 experts), sex (García-Santos et al., 2017) or age, there are even studies that assess these
22 variables comparing them among referees of different categories (Alker, 1973; Gencay et
23 al., 2015).

1 In the studies related to the physical/physiological demands the majority are associated
2 with analyzing HR, independently of the referee's category (Nabli et al., 2019), age
3 (Matkovic et al., 2014) and sex (Vaquera et al., 2016). Moreover, they have studied the
4 relation between the referee's body composition and the competitive load (Leitch, 2002;
5 Vaquera et al., 2017), as well as the distance covered by the referee during the different
6 quarters and during the game (Allegretti et al., 2015; Borin et al., 2013; García-Santos et
7 al., 2019; Nabli et al., 2016) and the energy spent during the competition (Nabli et al.,
8 2017). To a lesser extent there are studies related to lactate (Nabli et al., 2016), no doubt
9 due to the complexity of performing them and the impact they have on the referee. Lastly
10 there are a few studies focused on the referee's neuromuscular variables (Bonganha et al.,
11 2013; García-Santos et al., 2019; Leicht et al., 2019), which are currently of great interest.
12 However, no studies have been found that relate load parameters with competitive
13 variables, the characteristics of the players and teams, or the success or failure of the
14 decision-making. A surprising situation, since it would be helpful to observe the relation
15 among the competitive variables, decision-making and the **physical/physiological**
16 demands experienced by the referee. It would also be interesting to know how the
17 different stressful situations that arise in competition affect the values of
18 **physical/physiological load**.

19 Finally, the research associated with the psychological profile is closely related to the
20 different stressful situations (protests, errors, conflictive situations...). Similarly, this type
21 of variables is influenced by the characteristics of the players and teams, as well as the
22 correctness or not of the decision-making which may trigger conflictive situations. If we
23 consider the level of the referees in these studies we find research exclusively focused on
24 national referees (Jaenes et al., 2012) and those in training (García-Santos et al., 2017;

Ritchie et al., 2016) and in other cases, comparing their level (international, national and in training) (Arbinaga et al., 2019; De Almeida et al., 2018) and even different nationalities (Anshel & Weinberg, 1995). This is an interesting aspect, as it can be observed that the novice referees present higher values in stressful situations (Ritchie et al., 2016), as they are not so used to living with their mistakes (McMahon & Mildenhall, 2012), neither to endure the different protests that can arise.

Table 5 near here

4. CONCLUSIONS

The present study made it possible to carry out a detailed analysis of the literature devoted to the basketball referee in the SCOPUS and WOS databases. The findings have led to the establishment of three main groups of variables that determine the referee's performance during competition.

To be able to make correct decisions referees have to develop a series of technical skills associated with the assessment of contacts, violations, the control of the game or the mechanics of the movements that determine the success of their intervention in the game. In addition, it is necessary that the referee made a training program simulating the real game conditions so that his decision-making is adapted to the real-time space and to solve different situations that can arise in a basketball game.

It is also necessary to take into account the variables of physiological and physical load that indicate the level of effort and the physiological characteristics of the referee during the development of the game. According to the analysed studies it is possible to enhance the importance of HR, kinematics variables (speed, distance covered, accelerations and decelerations) and neuromuscular variables (player load and metabolic

energy). In addition, it is needed of controlling for referee's anthropometric measures that may affect his/ her movements and actions.

Lastly, it is important to identify and define the different stressful situations that can arise in competition, to be able to counteract them and live with them during the referee's intervention. After the systematic revision, the specify situation are the referee's mistake, the presence of an observer or technician, rough situation between players, players, coaches or fans protesting, and end of game situations solved via IRS (Instant Replay System) or after a referee's consensus.

All of the above, should be related with the experience and competence that all referees should acquire to be able to develop their functions as successfully as possible, using the different tools and methods detailed in the studies analyzed to help them to improve their vision and their role in competition.

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DECLARATION OF INTEREST STATEMENT

The authors report no conflicts of interest.

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1 **Table 1. *Quality Score of Investigations (Law et al 1998)***

<i>Q1</i>	Was the study purpose stated clearly?	1=Yes	0=No
<i>Q2</i>	Was relevant background literature reviewed?	1=Yes	0=No
<i>Q3</i>	Was the design appropriate for the research question?	1=Yes	0=No
<i>Q4</i>	Was the sample described in detail?	1=Yes	0=No
<i>Q5</i>	Was sample size justified?	1=Yes	0=No
<i>Q6</i>	Was informed consent obtained? (if not described, assume No)	1=Yes	0=No If not applicable, assume NA
<i>Q7</i>	Were the outcome measures reliable? (if not described, assume No)	1=Yes	0=No
<i>Q8</i>	Were the outcome measures valid? (if not described, assume no)	1=Yes	0=No
<i>Q9</i>	Was method described in detail?	1=Yes	0=No
<i>Q10</i>	Were results reported in terms of statistical significance?	1=Yes	0=No
<i>Q11</i>	Were the analysis methods appropriate?	1=Yes	0=No
<i>Q12</i>	Was importance for the practice reported?	1=Yes	0=No
<i>Q13</i>	Were any drop-outs reported?	1=Yes	0=No If not applicable, assume NA
<i>Q14</i>	Were conclusions appropriate given the study methods?	1=Yes	0=No
<i>Q15</i>	Are there any implications for practice given the results of the study?	1=Yes	0=No
<i>Q16</i>	Were limitations of the study acknowledged and described by the authors?	1=Yes	0=No

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Table 2. *Decision-Making Studies.*

Authors & Year	Sample		Number of Subjects	Number of Games/ Cases/Seasons	Aim	Variables	Main Results	QS (%)
	Level	Gender						
Karacam & Adiguzel, 2019			64		To examine the relationship between performance scores and basketball referees' self-efficacy levels with some demographic variables	Self-efficacy scale and demographic variables (age, experience, n° games, score)	A positive significant relationship was found between basketball referees' physical fitness, game knowledge, decision-making, pressure, communication, REFS total score, and their performance scores and the variables age and the number of games refereed. Moreover, a positive significant relationship was found between basketball referees' physical fitness, game knowledge, decision-making, pressure, communication, and REFS total score and their performance scores.	78.6
Morgulev et al., 2018.				250 cases	To analyze the reason for calling fouls in attack	Difference in the body composition of the players, reputation of the player, reputation of the team, situation of the team (local or visitor).	There were no significant differences regarding this type of variables to call a foul in attack or legal position defense.	71.4
García-Santos et al., 2017.		4 M 2 F	6		To understand the differences in relation to the gender of the referees in their intervention in the game.	IOVAB. Uniformity and fitness, mechanics, violations, personal fouls, collaboration with the companion and control of the game.	There were no significant differences in any of the blocks, except the mechanical movements of the head referee that are performed better by the women.	80.0
García-Santos & Ibáñez, 2016.	14 Experts		14		To elaborate and validate an instrument to assess a referee's performance (IOVAB).	Uniformity and fitness, mechanics, violations, personal fouls, collaboration with the companion	The results on validation and reliability show that it is only necessary to eliminate 6 items of the 50 that compose the instrument. The final document was found to be valid and reliable to be applied to referee training.	92.9

Gencay et al., 2015.	76	To ascertain the influence of teams, players and spectators on referees' decision-making.	and control of the game. The Basketball Officials' Favoritism Questionnaire (BOFQ)	The present paper has also revealed that basketball officials with positive sporting backgrounds (experience as players at professional or amateur level) are less affected by spectators. There were, however, no correlations found between the years of officiating experience and the factor of influence of individual players, teams and spectators.	100
Gift, 2015	6.538 games	This study investigates the impact of past performance evaluations on future decisions involving judgment. It analyzes the decisions of highly skilled and highly monitored referees regarding offensive fouls and violations in the National Basketball Association.		Results are inconclusive for subsequent changes in scrutiny toward the original violating team. The analysis provides a non-experimental test of sequential bias on elite employees working under strict performance standards, and suggests a likely role for sequential judgment effects in other areas of economic activity.	85.7
Gift & Rodenberg, 2014.	4 seasons	The interaction between players and referees in the National Basketball Association (NBA) provides a real-world laboratory that allows for observation and testing of implicit height-based biases	Referee Height, Player Characteristics and Player Performance Statistics.	They find evidence that referees exhibit height-related bias in their personal foul calls in a manner resembling the Napoleon Complex. We also find that increased foul calling by shorter referee crews does not vary with player height. This finding may be true in an absolute sense or it may be a function of our sample, which does not contain a substantial number of players who are shorter than the referee crew.	85.7
McMahon & Mildenhall, 2012.		The objective of this article is to reflect on the sport science research findings related to decision-making and	Decision-making errors	Specifically, it reflects on the mechanisms that have been discussed as influential in leading to these errors, and the responses to these errors. It presents the general view that officials are human information processors	64.3

			decision-making errors in sports officials (judges, umpires, referees).		both vulnerable to, and in some cases benefitting from, the limitations of their system.	
Hancock et al., 2011	14 M 6 F	20	The purpose of this research was to investigate patterns of observational learning implemented by team sport athletes, coaches, and officials.	The FOLQ evaluates three functions of observational learning (skill, strategy, and performance)	Coaches scored highest on the skill and strategy functions, while officials scored highest on the performance function. Another contribution is the confirmation that observational learning is not influenced by gender or level.	92.9
Markoski et al., 2011			To develop software for decision-making in Basketball.	BBFBR Program	The current version of the BBFBR solution has implemented only a simple computation of the optimal path for the basketball referees in some actions. Therefore, it currently has only an educational purpose, which means that it can be used for training young basketball referees.	64.3
Anderson & Pierce, 2009.		365 games	To determine if the team and the number of fouls affects sanctioning a subsequent foul.	Fouls, Home Team, Away Team.	Results of the analysis indicate that officials are more likely to call fouls on the team with the fewest fouls, making it likely that the number of fouls will tend to even out during the game. This increased probability augments as the foul differential rises. In addition, there is a significant bias towards officials calling more fouls on the visiting team, and a bias towards foul calls on the team that is leading. The result is that the probability of the next foul being called on the visiting team can reach as high as 0.70.	71.4
Hack et al., 2009	20 M	20	This study examined attention processes in complex, sport-specific decision-making tasks without interdependencies from anticipation. Psycho-physiological and performance data	Event-related potentials obtained while judging game situations in foul recognition and a control task provided insight into focus of attention, selective attention, and	Results showed task-specific effects for advanced referees in components influenced by attentional focus and selective attention. Experts also seemed to profit from superior top-down strategy and were able to evaluate the stimuli more rapidly. These findings are discussed in connection with current models in neurosciences and theories of referee research.	85.7

			recorded from advanced and intermediate level basketball referees were compared.	processing strategy (top-down vs. bottom-up).		
Rodenberg & Lim, 2009.	77	654 games	To analyze if the referees had negative effects on the performance of the Dallas Mavericks.	z-Score	It found that no NBA referee had a significant adverse effect on team performance or exhibited bias against the Dallas Mavericks when considering all games (regular season and playoffs). However, when analyzing only the 80 playoff games involving the team, one example was found of an NBA referee having a significantly adverse effect on team performance.	71.4
Brand et al., 2006.	121		Referees had to make foul decisions for each of 18 videotaped scenes (contact situations).	Decision-Making	Results showed that referees in the condition with the removed sequential context awarded more rigorous sanctions than their colleagues.	71.4
Proios & Doganis, 2003.	55		The purpose of the present study was to investigate the effect of experiences of active membership and participation in decision-making processes and age on moral reasoning and goal orientations of referees in sport.	The Defining Issues Test and the Task and Ego Orientation in Sport Questionnaire. Experience and Age	The examination of mean scores did not show any specific trend of Task and Ego Orientation scores among referees in relation to age. No significant correlations between age and Task and Ego Orientation were found. The results were similar for Experience, with no apparent Goal Orientation trend. Again, no significant correlation between Experience and Task and Ego Orientation were found. Examination of mean P-scores by age, showed lower scores for adolescents (17 years of age) and higher ones for groups of adults up to 27 years of age and lower means for subjects older than 27. Finally, there appears to be an increase in the values of P scores by Experience. However, the correlations among age, experience, and P scores were not statistically significant	71.4
Alker et al., 1973	223	20 NBA 72 HG 69 MG 62 LG	This study investigates the characteristics of professional basketball referees which can account for their successful or	California Psychological Inventory (CPI).	There are more statistically significant variance differences between the groups of referees than there are mean differences on the CPI scales. These significant variance differences with one exception (Social presence) all exhibit the largest variance in the bottom rated officials. Dominance, responsibility,	80.0

unsuccessful performance
on the court.

sense of well-being, and achievement via conformance
exemplify this trend.

Note: *QS=Quality Score; M=Male; F=Female; HG=High Level; MG=Medium Level; LG=Low Level*

Table 3. *Physiological and Physical Demands Studies.*

Authors & Year	Sample Level	Gender	Number of subjects	Number of games/cases	Aim	Variables	Main Results	QS (%)
García-Santos et al. (2019)	International	6M 3F	9	15 games	The aim of the study was to analyzed the acceleration profile of basketball referees through UWB technology.	Accelerations and Decelerations during different periods of the game.	The results show that there are significant differences between the first and the fourth period in the duration of accelerations and decelerations and in the start speed of decelerations. Acceleration basketball referees profile can meet the demands of the game and properly analyze the predictors of performance.	86.7
García-Santos et al. (2019)	International	6M 3F	9	15 games	The purpose of this study was to identify the physiological, internal, and external demands placed on basketball referees using ultra-wideband (UWB) technology, in relation to the period of the game.	Internal and External Load	The results exposed that referees work around 62% HRmax and spend more than 80% of the game at intensities between 0–12 km/h. The first period was the period in which the greatest work demand was experienced in relation to these neuromuscular outcomes (11.92 PL; 3.61 Met; 277 Impacts). The results revealed a diminishment of internal and external demands on the referees over the course of the game.	93.3
Leicht et al. (2019)	National	2M 1F	3	1 game	The aims of this brief report were to: 1) document the activity demands of sub-elite basketball referees during a game; and 2) compare referee and player game activity demands.	External Activity: Player Load	Referees experienced an absolute PL of 310 ± 28 arbitrary units (4.2 ± 0.4 AU.min ⁻¹) during the game which was ~40% lower than that of the players. Referees exhibited a game PL profile dominated by the lowest PL band (~91%) with the players' PL profile shifted slightly towards higher bands.	73.3

Nabli et al., 2019 (Review)						The aims of the present narrative review were to summarize knowledge in exercise performance of basketball refereeing to help practitioners develop sports training programs and select appropriate testing, and to support researchers developing new studies in this field.	Physiological demands Physical demands Decision-making Mental fatigue Experience	The relevant studies (n=19) showed that referees cover ~5000 m during a game with mean HR of ~140 beats.min-1 (>75% HRmax) and oxygen uptake of ~52 ml.min-1.kg-1 (~86.19% VO2max). The YO-YO intermittent recovery test level 1 (YO-YO-IRT1) performance has revealed a direct validity to assess the intermittent aerobic activity as it was correlated to the on-field activity of the referees. The estimated referees EE during a game exceed 500 kcal (~5 kcal.kg-1.h-1). The threshold of low intensity and high intensity could be considered as lower than 3.8 METs and higher than 9.8 METs, respectively. The physical abilities of referees decrease gradually with the chronological age. However, older referees (>32 years old) have a significantly better quality of officiating than young referees. The perceptual cognitive demands of basketball refereeing are also discussed in the present review	85.7
Vaquera et al., 2017.	10 International	F	10	11		The current aims were to determine BC, and HR and RPE responses by female basketball referees during elite international competition.	BC, HR, RPE and experience.	The current investigation has demonstrated that elite female basketball referees experience significant cardiovascular and perceptual stress during international games that may be influenced by referee experience and BC.	86.7
Nabli et al., 2017	16 International	M	16			The aim of this study was to analyze the EE and the exercise intensity of basketball refereeing during an official game and determined as METs.	EE; METs, Time Motion Analysis.	During a game, referees spent a mean EE of 504.4 ± 77.7 kcal. A significant difference was observed between 113.5 ± 18.2 kcal in the 1st quarter and 137 ± 27.5 kcal in the 4th quarter (p<0.00). The averaged EE (~5 kcal.kg-1.h-1) corresponded to “moderate energy intensity” (~5 METs) with a large contribution of the aerobic energy pathway. In all, during 88% of the game the intensity was equal or lower than	86.7

Nabli et al., 2016.	16 International	M	16		This study aimed to examine the physical and physiological demands of basketball refereeing.	HR, Lactate and Distance covered.	Blood and	3.8 METs and in 12% it was higher than 9.8 METs which were considered as low to high-intensity thresholds, respectively. The energy profile studied in this research confirms that basketball refereeing may be regarded as a clearly intermittent-activity mode with a predominantly aerobic metabolism solicitation. Referees spent more time ($p<0.01$) walking (63.72 ± 2.02 min) than jogging (3.10 ± 0.29 min), running (4.24 ± 0.46 min) and sprinting (1.69 ± 0.24 min). Referees covered more distance ($p<0.01$) walking than jogging, running and sprinting across the quarters. Mean HR (74.89 ± 6.86 %HRmax) was not significantly different across the game 1 st quarter to 4 th quarter) and halves. [La] did not show significant changes when comparing the half-time (4.30 ± 3.92 mmol.L ⁻¹) and the end of the game (6.70 ± 4.90 mmol.L ⁻¹).	93.3
Nabli et al., 2016.	15 National	M	15	8	To examine the relation between game performance, physiological responses, and field-test results in Tunisian basketball referees.	Time-motion analysis, HR and Blood Lactate, Yo-Yo Test.		This study showed that (1) the YYIRTL1 performance is a moderate predictor of game physical performance in U-19 basketball referees and (2) referees' RSA correlates with the amount of HIA performed during the 2nd half, which represents the ability to keep up with play.	80.0
Vaquera et al., 2016.	27 International	18M 9F	27	18 games	The aim of this study was to investigate the impact of sex on cardiovascular responses of referees during elite international basketball competition.	Average relative exercise intensity.	HR,	Female referees exhibited lower average game HR (156.8 ± 10.2 vs. 163.6 ± 11.6 bpm, $p<0.05$) and exercise intensity (86.2 ± 5.5 vs. 89.5 ± 6.0 %HRmax, $p<0.05$) compared to male referees.	86.7
Vaquera et al., 2016.	31 International		31	38 games	The aims of this study were to determine the HR response of referees during men's Eurobasket	HR, BC.		The heart rate was directly associated with REF's anthropometric features and years of experience. However, it did not show any association with different game variables such	93.3

				Championship and identify relationships between body composition and other match variables as predictor of HR		as: total scores, differences of scores among teams, duration of the game or ratio time/point ratio. The study also showed that variables of triceps skinfold (β : 1.33; $P<0.00$), years of experience (β : -0.40; $P<0.05$) and fat mass (β : -2.51; $P<0.00$) were the variables that significantly predicted the physical performance.	
Allegretti et al., 2015.	6M	6		The aim of the study was to describe the distance covered per quarter, during official games, by elite basketball referees, using a computer aided video-based tracking system.	Distance covered	The referees covered on average 1130.03 m (± 160.72 m) per quarter game. Most of the time they remained standing or with small lateral movements, corresponding to 87.1% of the total game duration.	80.0
Bayón et al., 2015.	Experimental and Control	24		To ascertain the difference between groups after a training program.	RSA, Height, Weight, % fat, BMI.	The improvements in the RSA of basketball referees will clearly enhance their fitness as well as their kinanthropometric values. Both groups improved after the training program.	86.7
Matkovic et al., 2014.	31 National	31	1 Season	The objective of this study was to establish physiological loads elite basketball referees sustain during competitive games	Age, HR, HR zones	There were no significant differences between younger and older referees in the physiological load they sustain during the games. The average HR during a game was 131.52 ± 9.10 bpm, that is, $77.34 \pm 6.05\%$ of the HR at the anaerobic threshold. It was established that the referees spent 50% of the total game time in zones of high aerobic load (extensive and intensive aerobic zone), whereas if only the time during the quarters is examined, then this percentage amounts to 60%. The referees spent only 1-2% of the total game time in the anaerobic energy process load zone.	93.3
Vaquera et al., 2014.	26 International	26	48 games	The purpose of the study was to describe heart rate responses of referees	HR, %HRmax, HR zones	The data suggest that international basketball referees are unable to maintain initial exercise intensity for four successive quarters of	86.7

				during a major international basketball championship		championship play. This is in contrast to available data suggesting elite players are able to maintain or increase exercise intensity as games progress.	
Bonganha et al., 2013.	17 International 20 National	37		To characterize the metabolic and neuromuscular performance and body composition of Brazilian elite referees.	Body Composition, Neuromuscular variables, metabolic parameters and referee level.	There were no significant differences in any of the variables according to referee's level. Compared to the players the referees' results were lower in metabolic and neuromuscular variables and higher in body composition.	80.0
Borin et al., 2013	16 International 2 National	18		To measure and evaluate the distance covered by referees in a game by measuring the number of interruptions, %HR, and [lac] in different phases of competition and in different MPs.	HR, Distance covered, Blood Lactate, Competition.	Regarding the distances covered, we observed significant differences ($P<0.05$) in the 1st, 2nd, and 3rd MPs between the FP and the other two phases (SP and QP) throughout the game, between each phase; in the 4th MP, a significant difference was found when comparing the QP and the other two phases. Comparing the periods within each phase, we found that a greater distance was covered in the 4th MP in relation to the 3rd MP during the FP. No significant differences were found among the remaining variables.	86.7
Rupcic et al., 2012.	31 National	31	1 season	The main object of this research was to determine the existence of statistically significant differences in the physiological load of referees considering the period of the basketball game	Average heart rate; maximum heart rate, energy consumption (kcal/min).	Given the obtained results of univariate variance analysis it was concluded that there are no statistically significant differences in the physiological load between the first and second half – time, or between particular quarters of basketball games.	71.4
Rupcic et al., 2011	31 National	31	1 Season	The purpose of determining differences in anthropological profile of basketball referees	BC, Quality and Experience	According to our results basketball referees differ only in the variables for the assessment of motor abilities, while there were no statistically significant differences in the tested	85.7

					according to their chronological age.		morphological characteristics and functional abilities regarding referees' ages. To conclude, investigated basketball referees were all physically well prepared, meeting the high standards of physical conditioning-motor preparation needed for the basketball games at the highest national level.	
Leicht, 2008.	7 International	6M 1F	7 referees	8 games	The aim of this study was to examine the physiological demands of basketball refereeing during international competition.	HR (bpm), %HRmax, %Time to HR	There were no significant differences between quarters for any variable. Referees, using a two-referee per game format, worked at an average HR of 150 bpm (range 110—181 bpm) for each quarter of the game, equalling a relative intensity of >70% HRmax for most (~76%) of each quarter.	80.0
Leicht, 2007.	25 National	25M	25		The aim of the study was to document the aerobic power and BC of elite basketball referees.	BC, Aerobic Power	Elite basketball referees demonstrated significantly greater aerobic power and similar body composition to the general community. In the euhydrated state, adult provided valid measurements of body fat% in elite basketball referees.	71.4
Leicht, 2004.	1 National	1M	1		This case study examined the cardiovascular stress experienced by an elite basketball referee during national competition games	Age, BC, HR (Cardiovascular stress)	The average heart rate was similar for all games (73%) of HRmax and was experienced for most (>63%) of the game. Similar relative exercise intensity was demonstrated regardless of game play (men vs. women) and officiating type (two or three referees). Further study is needed to document the physiological characteristics of elite basketball referees for better performance	64.2

Note: *QS=Quality Score; M=Male; F=Female; UWB=Ultra-Wide Band; PL=PlayerLoad; METs=Metabolic Equivalents; HR=Heart Rate; HRmax; Maximum Heart Rate VO₂max=maximum rate of oxygen consumption; BC=Body Composition; RPE=Rating Perceived Effort; EE=Energy Expenditure; [lac]=Blood Lactate Concentration; RSA=Repeat Sprint Ability; HIA=High Intensive Accion; MP=Match Period; FP=Final; SP=Semifinal; QP=Qualifying; bpm=beats per minute.*

Table 4. *Psychological Demands Studies.*

Authors & Year	Sample				Aim	Variables	Main Results	QS (%)
	Level	Gender	N° subjects	N° games/cases				
Arbinaga et al., 2019	30 National 124 Referees in training		154 referees		1- To determine the existence of differences in the scores when assessing burnout in soccer compared to basketball referees and 2.- To analyse if the scores on the resilience scale can act as a protective factor against burnout syndrome.	Social (Sex, Year of birth, Civil status) Sports (Type of sport, experience, Training, Injuries, Burnout, Resilience	Soccer compared with basketball referees show greater emotional exhaustion, depersonalization and personal fulfilment. Those who obtain high scores in resilience (29.8%), compared to those who obtain low scores (70.2%), show less emotional and personal realization; but do not show differences in depersonalization ($p = .561$). Soccer referees present a greater risk of obtaining scores that indicate low resilience compared to basketball referees.	93.3
De Almeida et al., 2018.	236 Regional 111 National 44 International	263M 128F	308 referees 83 officials		The aim of this study was to verify the psychometric properties of the BRUMS mood scale for basketball referees, with performance inside court or as table officials, through Exploratory Factor Analysis (EFA).	BRUMS scale	The results indicated that the BRUMS-AB scale has good psychometric properties that give it evidence of validity and reliability for its use in the context of basketball refereeing.	93.3
García-Santos et al., 2017.	6 referees in training	4M 2F	6		To ascertain the differences in the stress variable according to the gender of the referee.	LISEA questionnaire.	In all cases women are more affected than men both before and after the game. As is shown, women are more influenced by the name of the coach, the players, the ranking of the team in competition, the refereeing companions, the venue, the court where they referee and the presence or not of a game delegate.	80.0
Ritchie et al., 2016.	108 Referees in training	102M 6F	108	9 cases	The present study examined the effect of situation criticality on stress levels experienced by officials.	Stress Appraisal Measure (SAM).	Results revealed that situation criticality has an effect on officials' perceived stress levels. Both threat and challenge appraisals were positively correlated with perceived stress. Overall, these findings indicate that officials'	92.9

Anshel et al., 2014.	64 Regional 61 Referees in training	108M 17F	125		The purpose of this study was to externally validate and test a conceptual transient model involving six paths that linked sources of acute stress to avoidance and approach coping styles among Turkish basketball referees.	Basketball Officials Stress Inventory (BOSI)	stress levels fluctuate within games depending on score differential and time of game. The findings encourage officials to recognize and manage their stress, possibly through their appraisals. Results indicated that the model achieved a good fit and that all paths tested simultaneously were significant. The distractions stressor was positively related to subpar performance, which, in turn, was positively related to verbal abuse. Verbal abuse was negatively associated with an avoidance-cognitive coping style and positively related to the approach-cognitive coping style. The results also supported a crossover effect of both avoidance-cognitive and approach-cognitive on approach-behavior.	93.3
Anshel et al., 2013.	Referees in training	M	1496		The purpose of this study was to develop and calibrate the Sources of Acute Stress Scale for Sports Officials (SASS-SO) using the Rasch model.	SASS-SO	Using the Rasch model, the level of sources of stress item, difficulty and individual's level of acute stress were estimated. Infit and Outfit measures were within the appropriate range supported by the unidimensional structure of the SASS-SO. The two most severe sources of acute stress were "I made an incorrect call" and "I was out of position." The two least severe sources of acute stress items were "I received verbal abuse from players" and "My supervisor/evaluator was present."	100
Jaenes et al., 2012.	59 National	57M 2F	59	15 cases	The objective of this study was to draw up a list of stress related situations both before and during the game.	Stress Situations. LISEA	The survey showed a very high accuracy value (.897) Results show that different stress sources have a varying influence depending on the moment in the competition, except for one item.	78.5

Stewart et al., 2004.	324 Training	312M 12F	324	The purpose of this study was to survey certified high school basketball officials during midseason to assess whether the sources and magnitude of perceived psychological stress would be consistent with previous studies of officials in other sports.	Adaptation OSOS, Likert scale 0-3.	The highly rated stressors among the various factors were "players and coaches protesting decisions" and "having a bad game." These scores can be interpreted as approaching "moderate" stress. Stressors near the middle of "mild" to "moderate" stress were "having an aggressive game" and "making a bad call." In terms of percentage of officials responding "Strongly" to specific questions, "Dealing with players or coaches who protest a decision" was 24.0%, "Having a bad game" was 21.2%, "Dealing with over-excited or hostile coaches" was 19.0%, "Making a bad call" was 16.7%, and "Dealing with an aggressive game" was 16.7 % .	73.3
Kaissidis-Rodafinos & Anshel, 2000.	162 National		162	The authors examined the effects of situational appraisals (perceived control and intensity), coping styles (monitoring and blunting), and personal dispositions (optimism and self-esteem) on the approach and avoidance coping responses	These instruments measured self-reports of monitoring and blunting coping styles; optimism; self-esteem; and perceived stress, perceived control, and the consistency of approach and avoidance coping responses	The results were equivocal: The Greek referees were not consistent in using avoidance and approach coping responses across situations. Approach coping was more predictable than avoidance coping in accounting for both situational and personal variables.	64.3
Kaissidis-Rodafinos et al., 1998.	113 National		113	Referees were analyzed to compare the perceived intensity of stress and their responses during IT acute stressful situations.	Stressful Situations.	Australian referees considered the stressors, "Arguing With Players", "Arguing With Coaches", "Making a Controversial Call", "Verbal Abuse From Coaches", "Verbal Abuse From Players" and "Making a Controversial Call" to be significantly more stressful than their Greek counterparts. On the other hand, Greek referees, as compared to	71.4

Kaissidis-Rodafinos et al., 1997.	133 National	133			The aim of this study was to establish the ways in which coping style and situational appraisals are related to the consistency of using approach and avoidance coping strategies	Coping Style, Coping Strategies and perceived stress.	Australians perceived "Presence of Media" to be more stressful. Qualitative data revealed differences in the referees' perceived intensity of stress as well as in their thoughts and coping responses to these sources of stress. Findings indicated that: referees exhibited consistent avoidance, but not approach, coping styles; they used more avoidance than approach strategies; and they perceived stress to be positively correlated with approach, and negatively associated with avoidance, coping strategies. These findings suggest that individual differences exist in perceptions of stress (i.e. situational appraisals), controllability and coping styles among moderately and highly skilled basketball referees.	80.0
Anshel, 1995.	20 Experts	20			The purpose of this article is to describe the construction (Phase 1) and external validation (Phase 2) of a behaviorally anchored rating scale (BARS) for identifying and measuring competencies for basketball referees (BARS-BR)	BARS-BR.	The results lent support to the validation of the BARS-BR for assessing competence in basketball officiating.	71.4
Anshel & Weinberg 1995.	132 National	132M	132	15 cases	To compare the perceived sources of stress for American and Australian basketball officials.	The BOSSI consists of 15 items (stressors) from which subjects circle a number from 1 (not at all) to 10 (extremely).	The overall ranking of the sources of acute stress from the BOSSI indicated that making a wrong call, verbal abuse by coaches, threats of physical abuse, being in the wrong location when making a call, and experiencing injury were the top five sources of stress.	71.4
Rainey & Winterich, 1995.		667M 56F	723	15 cases	To ascertain the degree of stress of the basketball referee using a questionnaire	3-item-scale	The basketball referees responded to a survey that assessed stress related to officiating. Mean reported ratings were between "very little" and "moderate amount"; only 4% reported high stress. Results are consistent with other	57.1

Kaissidis- Rodafinos & Anshel, 1993.	38 National 26 Training	64	The purposes of this study were to: (1) identify the sources of acute stress that affect basketball referees, and (2) compare the degree of perceived acute stress between adolescent and adult Australian basketball referees.	The referees rated the intensity of 15 sources of acute stress they commonly experience during the game	accounts, suggesting that most sport officials experience low occupational stress. A MANOVA revealed that young referees were significantly more stressed than their adult colleagues about 'making a wrong call' and 'giving a technical foul.' Stressors ranked highest were 'threats of physical abuse', 'verbal abuse from coaches,' and 'making a wrong call.' Sources of stress ranked lowest included 'presence of media', 'making a mistake in mechanics' and 'verbal abuse by spectators'.	64.3
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Note: *QS=Quality Score; M=Male; F=Female; HG=High Level; MG=Medium Level; LG=Low Level*

Table 5. *Multifactorial Analysis*

Type	L	S-E		Ref Skills		Comp Variables		Team Charact		Players Characts		Game Know		Success Decision		BC		HR		Dis Covered		Met Energy		Lac		Neuro Variables		Stress	
		Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N
Decision-Making (16)	Int	5		5		2	3	2	3	1	4	2	3	5		1	4	5		5		5		5		5		5	
	Nat	1	1	1	1	2		1	1	1	1	1	1	2		2	2	2		2		2		2		2		2	
	Reg	3		3		1	2	1	2	1	2	1	2	3		3	3	3		3		3		3		3	1	2	
	Train	1		1		1		1		1		1		1		1	1	1		1		1		1		1	1	0	
	Exp	1	1	2		1	1	1	1	1	1	1	1	1	1	1	1	2		2		2		2		2		2	
	Mix	1		1			1		1		1		1	1		1	1	1		1		1		1		1	1	0	
Physical/Physiological Demands (20)	Int	9		9		4	5	9		9		9		9		4	5	7	2	3	6	2	7	1	8	1	8		9
	Nat	8		8		6	2	7		7		7		7		6	2	5	3	1	7	4	4	1	7	1	7		8
	Mix	3		3		2	1	3		3		3		3		3		1	2	2	1	1	2	1	2	1	2		3
Psychological Demands (15)	Nat	5		5		1	4	5		5		5	5			5	5	5		5		5		5		5		5	
	Train	3		3		2	1	1	2	1	2	3	2	1		3	3	3		3		3		3		3		3	
	Exp	1		1		1		1		1		1		1		1	1	1		1		1		1		1		1	
	Mix	1	3	4		2	2	2	2	2	2	4	2	2		4	4	4		4		4		4		4		4	
Review (1)	Mix	1		1		1		1		1		1		1		1	1	1		1		1		1		1		1	

Note: *L=Level; Int=International; Nat=National; Reg=Regional; Train=Training; Exp=Experts; Mix=Mixed; Y=Yes; N=No; S-E=Self-Efficacy; Ref Skills=Referee Skills; Comp Variables=Competition Variables; Team/Players Charact= Team/Players Characteristics; BC=Body Composition; HR=Heart Rate; Dis Covered=Distance Covered; Met Energy=Metabolic Energy; Lac=Blood Lactate; Neuro Variables=Neuromuscular Variables; Stress=Stressful Situations.*



Figure 1. *Diagram of Search Process*

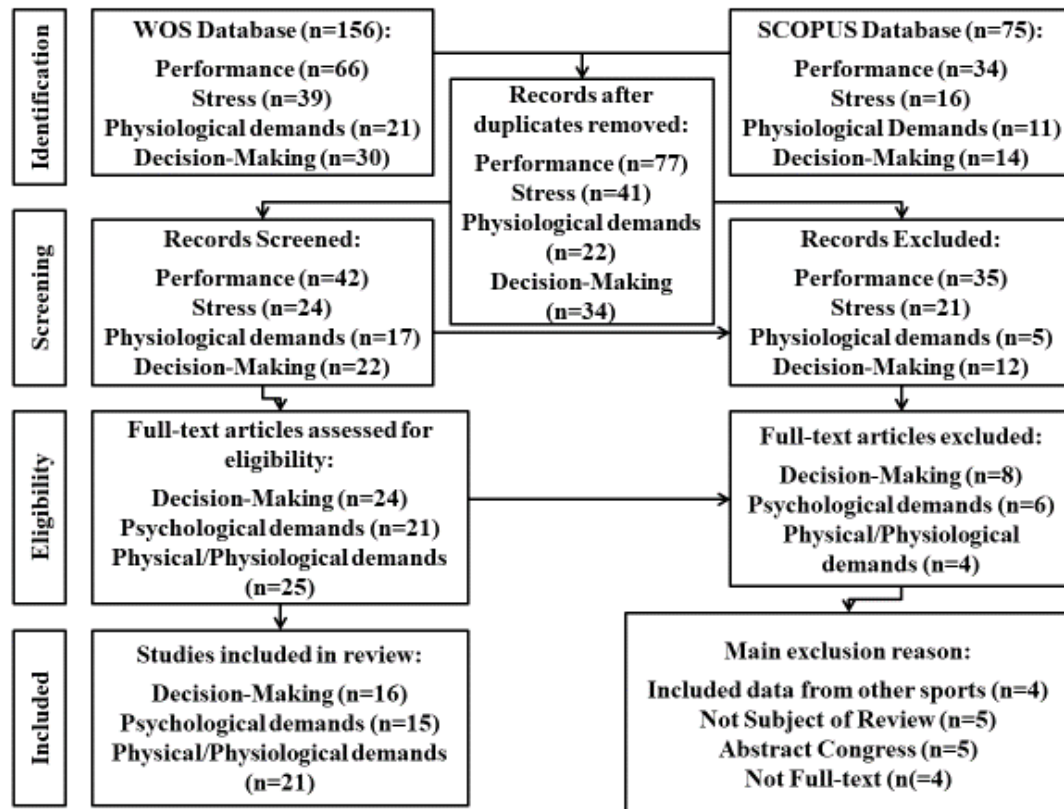


Figure 2. *Flow chart of the procedures used for the article search.*

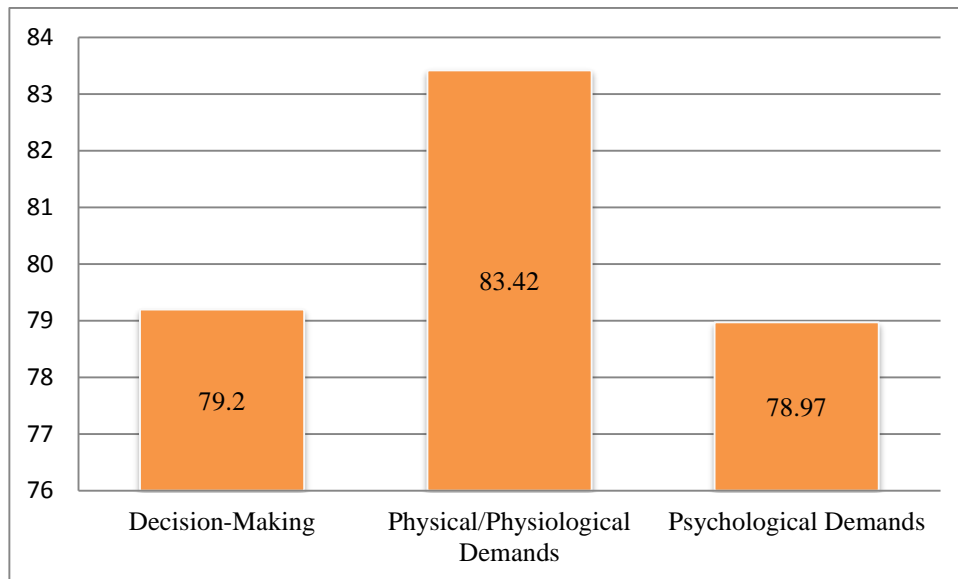


Figure 3. *Methodological Quality*



Figure 4. *Decision Making Profile*

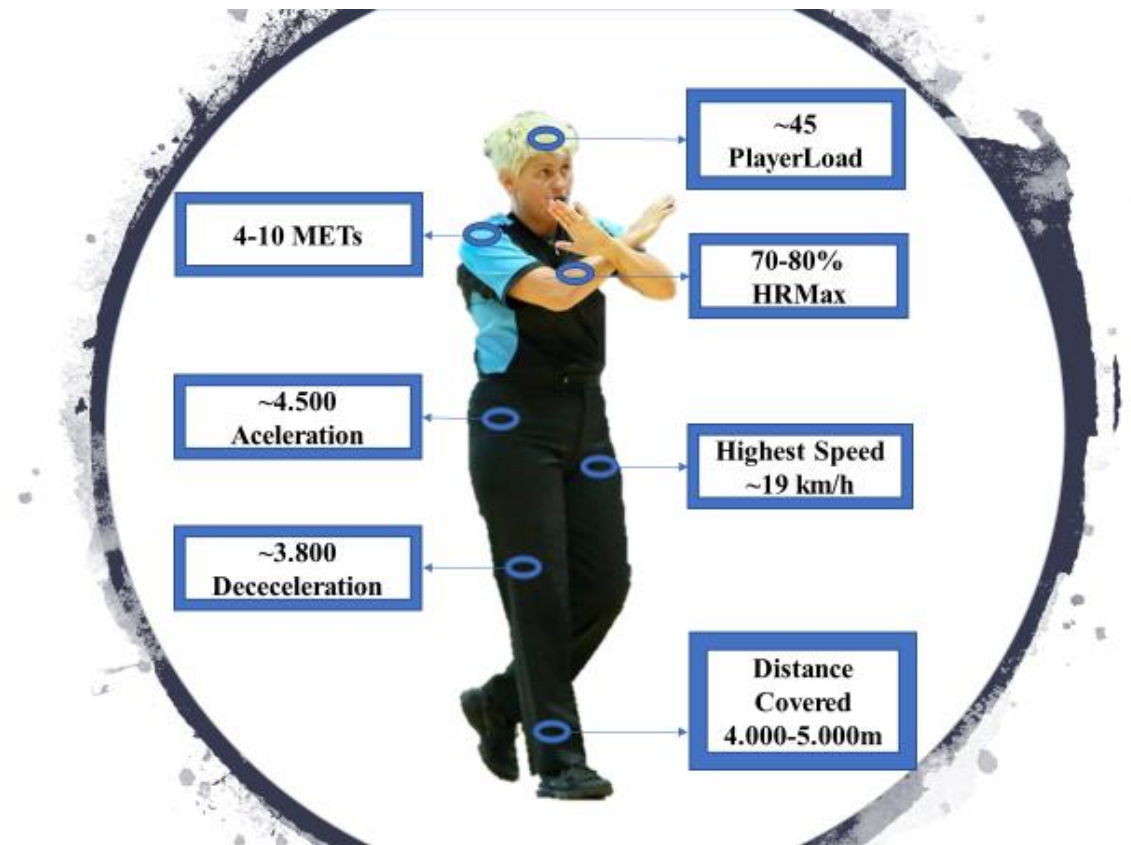


Figure 5. *Basketball Referee Physiological and Physical Responses during Game*

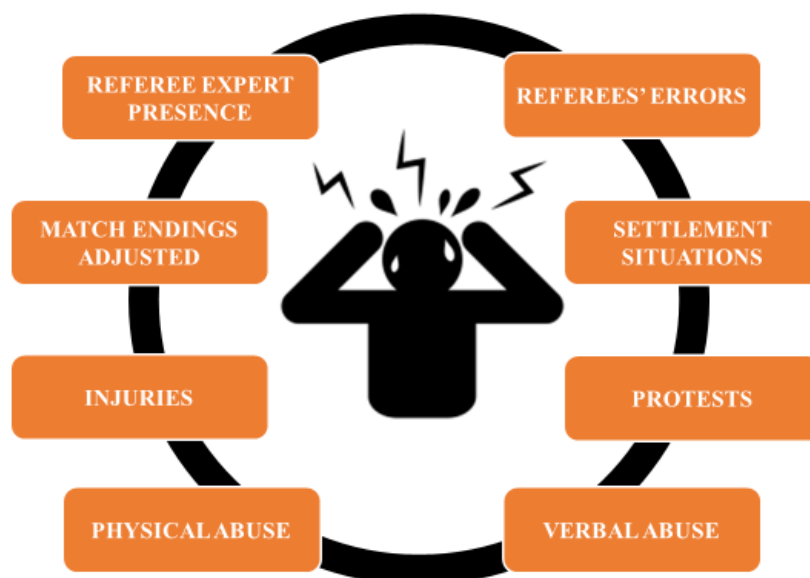


Figure 6. *Referee Stressful Situations*