Analysis of the FIFA's Model of Physical Evaluation Applied to the Soccer Referees

EXERCISE AND SPORTS MEDICINE CLINIC

Original Article

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ABSTRACT

Introduction: In order to control and select the referees for performance in professional soccer, the Fédération Internacionale de Football Association (FIFA), considered the accomplishment of physical tests. However, the initial proposal of evaluation suffered modifications with the passing of the years, and the current model seems not to be ideal to evaluate the referees, in accordance with the physical profile requirement demonstrated during the games. Objective: Therefore, the objectives of this study were: to identify the physical load of soccer referees in official games and to determine the physiological demands associates to the physical effort during the official games; and to analyze the current model of physical evaluation of the soccer referees. Conclusion: Referees cover an average of 10,000 meters during a game, being most of the time done with activities of low intensity. The activity profile is intermittent and the energy demand has predominance of the aerobic system, with important participation of the anaerobic system. The current tests applied are not compatible with the standard of physical requirement of a referee during a soccer game.

Keywords: activity profile, physical load, physical tests.

INTRODUCTION

The evolution of soccer athletes' physical preparation had as consequence greater game physical load, influencing soccer referees as well. The *Fédération Internacionale de Football Association* (FIFA) with the purpose to follow-up this evolution, implemented many strategies with the purpose to improve the refereeing level. In 1989, it suggested the application of a physical tests' battery to the evaluation of referees[1]. In 1990, during the World Cup, FIFA determined that the maximum age for a referee to be part of its team would be 45 years, and not 50 years any more.

One of the pioneer investigations on the functional evaluation of a referee was developed by Rontoyannis *et al*.[1] When this research was developed in 1992 in Greece, the test battery designed by FIFA was composed of four tests: one which measured aerobic endurance (Cooper test), two which measured anaerobic endurance (two 50m runs and two 200m runs applied in alternation) and another one which measured agility (4 x 10 m), an event which was suppressed in 1995.

In the last 10 years, the test battery developed by FIFA has been intensively analyzed, and the change of the test which measures aerobic endurance (Cooper test) for a more specific one, even considered by researchers; that is to say, which evaluates aerobic endurance of referees in motor actions closer to those performed b them during a game[2-6].

Before 2001, the tests consisted of two 50m runs and a 12 minute Cooper running test, in this order. After 2001, the tests' order was altered: the 12-minute Cooper test was performed first, then two 50 and 200m races were performed in alternation: 50, 200, 50 and 200m races[7]. However, Mallo *et al.*[8] demonstrated that these tests were poor evaluators of the referees' physical performance during the games. In a trial to overcome this problem, in 2006 FIFA established a new test battery aiming physical evaluation of the referees and their assistants, which includes 20 150m sprints and six 40m sprints[9].

However, a deeper analysis of the proposed tests having the referee's physical dynamics as reference, show these are not suitable, clashing with a basic point of the physical evaluation, which is its specificity, an idea which is also shared by Mallo*et al.*[10]. A physical evaluation should simulate the most the real situation of the activity to be assessed; thus, it is crucial to understand the pattern of physical demand of the modality.

Thus, the aims of thisstudy were: to identify the physical load of soccer referees and to determine the physiological demands associated with the physical exertion performed during the official games and to assess the current physical fitness model of the soccer referees.

Movement profile of the soccer referees in official games

Over the last years, many studies have been performed with the aim to know the movement profile of soccer referees, as expressed in table 1.

Table 1 data present mean distance of over 10km completed by a referee during an official game. On the other hand, it is worth highlighting that in special situations a referee will be able to reach 13km, as pointed out in a study by Castagna*et al.*[18], the referee should be hence physically prepared for this physical demand.

There are many hypotheses which could justify the differences observed in the distances completed by the referees during a soccer game. According to Castagna*et al.*[18], these differences could be due to their physical fitness level as well as training status. Krustrup and Bangsbo[4], Castagna *et al.*[27]and Castagna and D'Ottavio[28] state that good aerobic fitness is strongly connected with the total game coverage and with the main game activities performed by elite referees during the competition. The differences in game style

Table 1. Distance completed by referees during a soccer game.

Competition	Games (n)	Age (years) mean ± SD	Distance (m) mean ± SD	Reference
Japanese Soccer League	10	-	10.168 ± 756	Asami *et al.* [11]
Referees of International Level	7	-	9.736 ± 1.077	Asami*et al.* [11]
English League 1st Division	14	-	9.440 ± 707	Catterall*et al.* [12]
Tasmanian State League	10	-	9.408 ± 838	Johnston and McNaughton [13]
São Paulo State Championship Under 20	8	26.7 ± 4,13	9.351 ± 1.022	Oliveira *et al.* [14]
Paraná State Championship A Series	9	-	9.209 ± 629	Da Silva and Rodriguez-Añez[15]
Italian Championship A Series	33	37.8 ± 2.1	11.469 ± 983	D'Ottavioand Castagna[16]
Italian Championship A Series	18	37.5 ± 2.14	11.376 ± 1.600	D'Ottavioand Castagna[17]
Danish League 1st and 2nd Divisions	27	38 (29-47)	10.070 ± 130	Krustrupand Bangsbo[4]
Italian Championship A Series	13	37 ± 3	12.956 ± 548	Castagna*et al.* [18]
European Cup	13	38 ± 3	11.218 ± 1.056	Castagna*et al.* [18]
Paraná State Championship A Series	12	35.5 ± 6.7	10.718 ± 890	Roman *et al.* [19]
Paraná State Championship A and B Series	29	38.9 ± 3.8	9.155 ± 70.3	Da Silva *et al.* [20]
English League 1st Division	778	(31-48)	11.534 ± 748	Weston *et al.* [21]
Italian Championship 6th and 7th Divisions	20	22.6 ± 2.4	11.394 ± 697	Ardigò[22]
World Cup Under-17	12	33.4 ± 3.8	11.059 ± 935	Mallo*et al.* [8]
English League1st Division	254	40.1 ± 4.9	11.622 ± 739	Weston *et al.* [23]
Paraná State Championship	-	34.4 ± 4	9.131 ± 256	Da Silva *et al.* [24]
São Paulo State Championship	-	27.3 ± 4.7	10.034 ± 841	Da Silva *et al.* [24]
Paraná State Championship A Series	13	38 ± 1.1	9.189 ± 125	Da Silva *et al.* [25]
English League	1.269	(22-49)	11.770 ± 808	Weston *et al.* [26]

(among countries) should also be considered when the results found in different studies are compared[5,29]. However, factors such as environmental conditions may also interfere in the total distance completed by the referees during a game.

In a review article on soccer physiology, Stølen*et al.*[30] concluded that considering the differences between positions, the soccer player covers mean of 10,000m during a game – a value similar to the one observed in soccer referees. Moreover, Weston *et al.*[31] did not observe differences between referees and players for the total distance covered in a game, high-intensity running and sprints. These similarities in actions in a game between referees and players corroborate the idea that soccer referees should be more professionally and specifically physically fit[6,32].

Motor actions of the soccer referees

It is very important to know the distance covered by the referee during a game; however, above all, it is crucial to know the kinds of motor actions performed during the game. Table 1 presents the absolute data of referees' movements; however, during a game there is great variation in movement and covered distance in each action.

The standard technique used to establish the referees' movements during a game was developed by Asami*et al.*[11]and adopted by other researchers in many studies[4,12,16]. The technique consists in filming the referee during the game and determining the total dislocation and distance covered in each motor action[33].

The division pattern of the motor actions performed by the referees during a game vary among the authors who discuss the topic, but is a consensus that during most of the time the referees perform low intensity activities (stopped, walking, trotting)[4,5,15,17].

The motor actions described in the investigation by Krustrup and Bangsbo[4]may be grouped in seven categories: stopped, walking, trotting, low-speed run, moderate-speed run, sprint (high-speed run) and dislocation backwards. The referee spends most of time walking during the game. In the study developed by Da Silva and Rodriguez-Añez[15], it was observed that Brazilian referees spent 58% of the total time of the game walking. In the study involving Danish referees, Krustrup and Bangsbo[4] also observed that these referees spent most of the time of the game walking, and that this motor action corresponded to 40% of the total time of the game. Further studies[5,11] have also reported significant dislocation percentage as walking. In those studies, Japanese and Portuguese referees walked 33% of the time of the game.

The second mostly used motor action is trotting. In the study by Da Silva and Rodriguez-Añez[15], the referees have moved 15% of the time of the game as trotting, the same percentage described by Krustrup and Bangsbo[4]. Rebelo *et al.*[5] describe a percentage of 25.9% in this motor action for Portuguese referees. However, other studies present much higher percentages for this motor action: 48% in Japanese referees[11]; 47% in English referees[12]; and 46.6% in Tasmanian referees[13].

When the data are assessed until this point, it is observed that these two motor actions rotate as the first or second main example of dislocation of soccer referees, in the sense that when one increases, the other decreases.

A motor action which presents speed higher than the dislocation as walking, but shorter than dislocation as trotting, is the dislocation backwards When the time of these three motors actions are summed up (walking, trotting and backwards), it is

verified that referees remain from 60 to 90% of the total time of the game using them[4,5,11,13,15].

According to Johnston and McNaughton[13]and Rebelo *et al.*[5], the referees spend more than 60% of the time of the game in low-intensity physical activities; that is to say, walking, trotting and in dislocation backwards. However, these authors did not consider the time the referees remain still during the game. When this time is added to the time the referees perform the low-intensity activities, it is observed that in the case of the referees studied here, this time represents 93% of the total time of the game. A study by Rebelo *et al.*[5], which presents the time the referees remain still and the classification of the motor actions, pointed that the referees remain in low-intensity activities in 95% of the total time of the game.

Moderate and high-speed runs do not represent the highest physical dynamics performed by the referees. It has been reported that the mean time of these dislocation examples ranges from 4 to 19% of the time of the game[4,5,11,13,15].

In a period which ranges from four to six seconds, the referees change their motor actions[4,12]. Thus, during the 90 minutes of an official game they perform mean of 1,268 different activities, among which, 588 are low-intensity activities (stopped, walking, trotting) and 161 high-intensity (running and sprint)[4].

These values are very close to the ones reported by Stølen *et al.*[30]for soccer players, who change their motor actions at every four to six seconds, totalizing 1,000 to 1,400 actions during one game.

Another important aspect is the mean distance of the referees' dislocation as running. According to data presented by Da Silva and Rodriguez-Añez[15], it was demonstrated that the highest frequency of sprints is concentrated in a 9.52 to 18.98m distance and that dislocation around 40m is very rare. D' Ottavio and Castagna[16] report that the analysis of the referees activity during the games show discreet high-intensity activities, never surpassing distances longer than 30 meters.

Physical performance during the games can be determined through a suggestion described by Krustrup and Bangsbo[4]. According to these authors, physical performance of referees during the games may be measured from the analysis of the sprints increase or decrease during the game, since the other motor capacities present low alteration when the referee is physically better prepared.

Heart rate and $\dot{V}O_{2Max}$ of soccer referees

Heart rate is another parameter to be assessed to know the physiological demands which the referees are submitted to during the game. Some studies which report the mean heart rate of soccer referees during official games are presented in table 2.

These values represent mean of 70 to 85% of estimated HR_{max}. To Krustrup and Bangsbo[4], the highest heart rate value which a referee reaches in a game corresponds to about 97% of his/her $HR_{max.}$ The data for soccer players show that the player's heart rate during the game is around 80 to 90% of HR_{max} – higher values, but close to the ones observed in soccer referees.

The metabolic demand of the soccer referee is classified as intermittent, which has as characteristics change in the activity rhythm and intensity, with variations in the level of physical exertion during the game. The energetic needs are predominantly supplied by the aerobic system; however, the participation of the anaerobic system, despite its lower quantity, is very important in some specific moments of the game[16].

Table 2. Mean heart rate of the referees during a soccer game.

Competition	Games (n)	Age (years) mean ± SD	HR (bpm)	Reference
Portuguese Championship	8	37 ± 6.6	150	Rebelo *et al.*[5]
English League 1st Division	14	-	165	Catterall *et al.* [12]
Tasmanian State League	10	-	162	Johnston and McNaughton[13]
Paraná State Chapionship A Series	9	-	141	Da Silva and Rodriguez-Añez[34]
Danish League 1st and 2nd Divisions	27	38 (29-47)	162	Krustrup and Bangsbo[4]
Paraná State Championship A Series	12	35.5 ± 6.7	156	Roman *et al.* [19]
Euro Cup 2000	31	40.2 ± 3.9	155	Helsenand Bultynck[29]

This difference in mean heart rate of the referee during the games could be partly explained by the difference in their cardiopulmonary capacity. According to Da Silva *et al.*[3], the mean $\dot{V}O_{2max}$ of the referees observed in their study was of 57.99 ± 3.11ml $(kg.min)^{-1}$. In another study using the same protocol and equipment, Da Silva and Rodriguez-Añez[34] found mean $\dot{V}O_{2max}$ value of 52.8 ± 6.82ml $(kg.min)^{-1}$. Castagna *et al.*[27] observed mean $\dot{V}O_{2max}$ of 49.30 ± 8.0ml $(kg.min)^{-1}$ for referees of the Italian First Division, using a multi-stage progressive protocol carried out under field conditions with K2 technology, different from the classical methodology used in the investigation by Da Silva *et al.*[3].

According to Barros Neto *et al.*[35], the professional soccer players from São Paulo who play in the lateral position present cardiorespiratory capacity higher than the ones who play in other positions, with mean $\dot{V}O_{2max}$ of 59.9 ± 8.25ml $(kg.min)^{-1}$ (n = 11). Mean value for soccer players is around 56.2 ± 6.23ml.$kg^{-1}min^{-1}$ (n = 77). When these result are compared with the ones obtained with referees, it is observed that soccer referees present mean $\dot{V}O_{2max}$ similar to the players', and only the lateral players present $\dot{V}O_{2max}$ higher than soccer referees.

Silva *et al.*[36] observed that adult players who play in Curitiba present mean $\dot{V}O_{2max}$ of 52.5 ± 7.49ml $(kg.min)^{-1}$ (n = 27), while players for the junior category present mean $\dot{V}O_{2max}$ of 62.1 ± 6.09ml $(kg.min)^{-1}$, (n = 42) lower than the ones from youth categories whose mean $\dot{V}O_{2max}$ is of 65.9 ± 4.81ml.$kg^{-1}min^{-1}$ (n = 19). Thus, the professional players who act in the professional championship from Curitiba present $\dot{V}O_{2max}$ similar to the soccer referees' from that state. The junior and youth athletes studied by Silva *et al.*[36] present O_{2max} higher than the referees'; which means these athletes stand support higher game intensities, requiring better physical fitness from the referees to act in these categories.

Analysis of the current physical fitness model of the referees

FIFA's newsletter # 1,013 dated from January 10, 2006 explains about the new physical test for referees, active from January 1, 2007. According to that determination, the evaluation consists of two tests: six 40m sprints and 20 150m sprints. On the first test, the aim is to evaluate mean running speed during the fast and repeated maneuvers of a game. On the second test, the aim is to measure the aerobic performance fitness in repeated intensity races. According to the new criteria, differentiated performance standards have been created according to levels, function and gender. Table 3 presents the reference values for the referees and assistant referees, while table 4 illustrates the values for female referees and female assistant referees.

Table 3. Reference values of the physical tests for the assistant referees of national and international levels.

	40 mrace		150 mrace	
	Running time (s)	Recovery time (s)	Running time (s)	Recovery time(s)
Foreign referees	6.2	90	30	35
Assistant referees	6.0	90	30	40
Local referees	6.4	90	30	40
Assistant referees	6.2	90	30	45

Table 4. Reference values of the physical tests for the female referees and female assistant referees of national and international levels.

	40m race		150m race	
	Running time (s)	Recovery time (s)	Running time (s)	Recovery time (s)
Female foreign referees	6.6	90	35	40
Female assistant referees	6.4	90	35	45
Female local referees	6.8	90	35	45
Female assistant referees	6.6	90	35	50

Regarding the 40m run, an interesting fact is that the demand level expressed by the time of test performance is higher for male and female assistant referees than to male and female referees respectively of the same level. Although the movement profile of the assistant referees has not been presented in this study, it was expected that the referees were demanded from the physical test, since they cover a longer total distance, distance at high intensity and present higher mean heart rate than the assistant referees during a game[37].

Concerning the 150m run, the time required for performance is 30 seconds for all levels of the male gender. In this test, the demand difference is in the recovery time, which is shorter for referees than to assistant referees, which shows higher demand for referees. According to Mallo *et al.*[10], increase in demand of the FIFA tests through reduction in the recovery time in the interval test from 40 to 35s and validity of this alteration in the protocol have not been determined yet.

Concerning the female referees, the same tests are applied, and the only difference is the time required for their performance. In the 40m run test, the recovery time between genders is the same, what changes is the minimum performance time for their completion. The performance time of the races is longer for women, which makes the demand level lower. In the 150m run, both running time and recovery time is longer for women, which shows that the demand level is much lower for women.

FIFA tests present different physical demand standards, according to gender. Since women can act as referees in male soccer games, the differentiation in performance proposed in practice becomes incoherent because the physical demand level of the game is the same. When the reference times between female and male referees of international level are compared, it is observed that for the 40m run the female referees are demanded a maximum time 6.66% longer than the maxim time for male referees. In the 150m run, these values are even longer: the maximum performance time and the recovery time for the female referees is 16.66% and 14.29% longer, respectively, than for the male referees.

The scientific discussion on the body composition and physical fitness of female referees to act in Brazilian elite soccer games recently had its first publishing[38,39]. Confronting the physical tests data of female referees [39] with the ones of male referees[32] from the same state federation and in the same year (2004), using the active FIFA tests at that time, the female referees presented performance 20, 17 and 23% lower than the male referees in the Cooper test, 12 minute run test, 50m run test and 200m run test, respectively.

If the minimum physical demand level of the tests for female referees is sufficient to make them illegible for the activity practice, there is no reason for demanding a higher level for male referees in the physical tests. On the other hand, if the minimum physical demand level of an official game for a soccer referee corresponds to physical tests reference values for the male referees, establishing a physical test with lower demand level for thefemale referees is admitting they are not apt to efficiently fulfill the tasks to which they have been accepted. These differences would be justified if the female referees were limited to act in female soccer games.

In a trial to minimize this situation, CBF determined that women who wish to act in male games of national or international level should present the men's indices in the physical tests (Newsletter # 44/2007-CA/CBF), being in agreement with the determination foreseen in the item 8 from Art. 4th of FIFA' Regulations.

CRITICAL ANALYSIS

The analysis of the investigations involving soccer referees in the scientific literature make us conclude that despite the changes proposed by FIFA in its physical tests battery, the current evaluation model does not meet the movement demands t which the referees are submitted[10,40].

An important principle which has been neglected in the designing of physical tests for referees both in the former and current models, is that they should be closer to the activity to be assessed and reflect the real situation of the practiced activity. As observed in the study reports on the profile of the activity performed by the referees, the movement is intermittent and there are occasional sprints of 30 meter the longest. There fore, there is no reason to prescribe a continuous running test or 150m sprints, since these stimuli are not partof the referees' movements during a game. Moreover, the literature does not offer any technical support for the use of this test for the anaerobic fitness evaluation of the soccer referee.

When the Cooper test was adopted, it was possible to determine the $\dot{V}O_{2max}$ or classify the physical fitness level of the referee according to his/her performance during the physical test. When the Léger, *Yo-Yo* endurance intermitent testand Yo-Yo intermitent recovery test, recommended respectively by Rebelo *et al.*[5], Da Silva *et al.*[3]and Krustrup and Bangsbo[4], are used, it is also possible to determine the $\dot{V}O_{2max}$ of each referee, that is, even applying the test in a group of referees, the results are individual and probably generate a more reliable physiological variable.

The physical test currently proposed by FIFA for measurement of aerobic fitness of referees does not provide any physiological variable and does not distinguish one referee from another, since there is a given time for the referee to complete each stage of the test. If one competes the 150m in 25 seconds, he/she will have to wait for the others to finish, even if the last one finishes the run in 29 seconds. Thus, one will rest for 35 seconds and another will rest for 31 seconds, and this will happen to the 10 laps around the track.

The results presented by the referees during the 12m run test previously used in the aerobic fitness evaluation of the referee presented correlation of r = 0.71 with the distance completed by the referee during the game[27]. Casajus and Castagna[41] observed moderate correlation between the 12m run test and the $\dot{V}O_{2max}$, ventilatory threshold and running velocity peak on treadmill. Therefore, referees with good cardiopulmonary fitness move faster during a game, since good aerobic fitness enables them to replace more efficiently the anaerobic energetic sources used after high speed dislocation during a game. Additionally, according to Castagna *et al.*[27], no correlation has been observed between the 50m and 200m tests which comprised FIFA's test battery and the total distance covered by the referees during a game, neither with the high speed dislocation performed by the referees during the game.

Another proposal found in the literature for the physical fitness measurement of referees during a game was suggested by Krustrup and Bangsbo[4]. These authors found a strong correlation between the Yo-Yo intermittent recovery test[42]and the high speed motor actions (r = 0.75) and with total distance (r = 0.66) performed by the referees during the game. Differently Da Silva *et al.*[3] suggest the use of the multi-stage 20m test by Léger *et al.*[43], since the O_{2max} obtained during this test *versus* the Cooper test did not present statistically significant differences.The Cooper test has as characteristic its completion on a running track, which is not always available.

Another comparison was made using the Cooper test *versus*the Yo-Yo test. In this study it was proved that the Yo-Yotest would be more suitable for the measurement of the aerobic fitness of the referees during the game, besides presenting high correlation with the high speed dislocation of the referee during the game[2]. The use of this test letus verify the increase of aerobic and anaerobic fitness ofthe referee. According to Weston *et al.*[6], after a physical training program with high intensity exercise sessions, the Yo-Yo intermittent recovery testwas more sensitive to measure the anaerobic fitness increase–the same observation made by Krustrup and Bangsbo[40].

Deep discussion has not been found in the researched sources on the need to measure the anaerobic fitness of the referees. Krustrup and Bangsbo[4] and Weston et al.[6] suggest that the referees are submitted to a specific training program with training sessions with intermittent loads of high intensity, and that this prescription would be sufficient to improve the energetic sources used by the referees during the game. However, scientific work involving soccer referees are very recent and scarce, if the studies involving soccer players are to be used as reference[3,11,12,15,16,44]. Thus, further studies should be developed with the aim to improve the physical tests used in the physical evaluation of referees following the physical evolution of the soccer players.

CONCLUSION

According to the data analyzed, the current physical evaluation modelof referees is not suitable to measure what it proposes to. Besides not evaluating aerobic fitness, which is an important physiological variable for referees, the 150-m running test is not compatible with the high-intensity stimuli which the referees are submitted to, which normally does not surpass 30-m races. Moreover, the difference in physical demand standards between genders is incoherent; since the aim of the tests is to pass the referees who are apt to efficiently act their function, the same excellence standard should be adopted, regardless of gender. The current physical fitness model presented a return concerning the initial proposals which established tests to evaluate aerobic fitness (Cooper test), anaerobic endurance (50m run) and agility (10m shuttle run).

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