Comparative analysis between maximum oxygen uptake and anthropometric profile in soccer players and referees

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Summary

The aim of this study was to analyze and compare the VO_{2max} and anthropometric profile of referees and professional soccer players. The population was composed by professional soccer players and referees, credited by Paranaense Soccer Federation (FPF). The sample was composed by 10 referees from FPF panel and 24 players from a team that operate in highest level of Paranaense championship, all male. Léger test (comes and goes) was used for field measurement of VO_{2max}. Anthropometric variables analyzed were: age, weight, height, and four skinfolds: subscapular, triceps, suprailiac and calf. Regarding anthropometric parameters, the referees had a mean age of 33.7 ± 3.1 years, height 177.9 ± 9.1 cm, weight 82.8 ± 12.8 kg and body fat of 15.5 ± 3.7%. The players had a mean age of 24.1 ± 3.4 years, weight of 78.1 ± 8.1 kg, height 178.2 ± 7.4 cm and body fat of 10.8 ± 2.6%. Functional evaluation showed that the average VO_{2max} from referees and players were 50.0 ± 1.3 and 56.7 ± 5.8 $ml.kg^{-1}min^{-1}$, respectively. There is significant difference between the age ($p = 0.0001$), body fat percentage ($p = 0.0002$) and VO_{2max} ($p = 0.0011$). It can be concluded that the referees are older and have a VO_{2max} less than the players. This coupled with higher body fat percentage of the referees is a factor that impairs their performance during the games.

Key words:
Soccer. Physiology. Evaluation.

Análisis comparativo del consumo máximo de oxígeno estimado y el perfil antropométrico entre árbitros y jugadores de fútbol

Resumen

El objetivo de este estudio fue analizar y comparar el $VO_{2máx}$. y el perfil antropométrico de árbitros y jugadores profesionales de fútbol. La población de este estudio fue integrada por jugadores y árbitros profesionales filiales de la Federación Paranaense de Fútbol (FPF). La muestra se compone de 10 árbitros del cuadro de arbitraje de la FPF y 24 jugadores de un equipo de primera división de fútbol Paranaense, todos ellos de sexo masculino. Para la medición del $VO_{2\ máx}$. se utilizó la prueba de campo de Léger. Las variables antropométricas estudiadas fueron: edad, peso corporal, altura y cuatro pliegues cutáneos (subescapular, tríceps, suprailíaco y pantorrilla). Con relación a la evaluación antropométrica, los árbitros de la Federación Paranaense registraron una edad promedio de: 33,7 ± 3,1 años, altura de: 177,9± 9,1 cm, peso corporal: 82,8 ± 12,8 kg y grasa corporal de: 15,5 ± 3,7%. Mientras que los jugadores registraron una edad media de: 24,1 ± 3,4 años, peso corporal de: 78,1 ± 8,1 kg, altura de: 178,2 ± 7,4 cm y la grasa corporal de: 10,8 ± 2,6%. La evaluación funcional mostró que el $VO_{2máx}$. promedio de los árbitros Paranaenses fue de: 50,0 ± 1,3 $ml.kg^{-1}$ min^{-1} y los jugadores de: 56,7 ± 5,8 $ml.kg^{-1}$ min^{-1}. Los resultados han expresado que existe una diferencia estadísticamente significativa entre la edad ($p = 0,0001$), el porcentaje de grasa corporal ($p = 0,0002$) y el $VO_{2máx}$. ($P = 0,0011$). Después de analizar los datos de este estudio se puede concluir que los árbitros son: de mayor edad, tienen un $VO_{2máx}$. menor que de los jugadores y un porcentaje de grasa corporal superior en relación a los jugadores. Está diferencia puede eventualmente poner en peligro el rendimiento del árbitro durante un partido de fútbol.

Palabras clave:
Fútbol. Fisiología. Evaluación.

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Introduction

Professional football is a growing rise worldwide, and in recent years there has been a growing interest in the biological sciences in further studies in different areas of knowledge related to this sport[1].

The predominant metabolic systems required in the soccer match course are aerobic and metabolic responses, similar to those found in endurance exercise[2]. However, motor actions include more activity without the ball during a game and are primarily aerobic activities while decisive, especially counter-attacks, are highly anaerobic. According to Hoff[3], there is a significant correlation between VO_{2max} and distance covered by players during a match. The VO_{2max} is defined as the maximum amount that an individual can capture, transport, and use oxygen set for work production performed by the human body[4].

For a soccer match occurs is necessary the presence of a referee's team beyond the 22 players. Thus, it was found that the aerobic metabolism is also severely required during matches in any competitive level of refereeing. Furthermore, it has been reported that VO_{2max} affects the distance covered during the match[5,6]. Although, high levels of VO_{2max} should be expected in soccer players and referees, because the intensity of the competitive activities, undertaken by players during the match, directly affects the distance and physical activities intensity developed by the referees during the match[7].

The aerobic fitness has been reported[5] as one of the most important factors contributing to the distance covered during competitions for elite referees. The aerobic energy production for referees and soccer players allows keeping high work rate for a long time during the match, and can also minimize a technical performance decrease. The figure of the distance covered by soccer referees during the match is seen as the parallel found in the midfield players[8,9]. However, the values reported for aerobic power shows that regardless of competitive level, referees have low values of VO_{2max} when compared with the soccer players[10].

Body composition is another important aspect to the athlete's fitness level in any sport, since high fat percentage may decrease the performance[11]. Besides harming the sports performance, a high level of body fat is related to the chronic degenerative diseases incidence such as diabetes and hypertension[12]. Accordingly, all information seeking evidence of body composition characteristics, motor performance and their interactions, may be important indicators of health and fitness level of the athlete[13].

The concern with the fat percentage soccer is not just limited to the players, as in the scientific literature began to appear scientific papers describing the referee's morphological profile[14,15]. To establish specific training programs is necessary to know beyond the activity physical demands, the anthropometric characteristics of the athlete to know if this is within the appropriate profile for the function[16].

During the scientific review for the reasoning of this study it was observed that almost all studies involving referees and soccer players were made separately. However, it is observed that due to interference, eg the players motor actions on the referees during the game, as we find in the literature the work being developed by comparing these directly, as with the work of 7 that evaluated the physiological demands of referees and compared them with the players during the English league matches. Because of these reasons, the objective of this study was to analyze and compare the VO_{2max} and anthropometric profile of players and referees.

Materials and methods

This study was characterized as descriptive and cross-sectional. The procedures used in this study follow the Resolution 196/96 of the National Health Council of Brazil, which deals with research procedures in humans. To conduct this study were selected 24 professional players by Operario Ferroviario Sport Club from Ponta Grossa city, that playing in highest level of Paraná state championsip. The referee's sample was composed by 10 professional referees accredited by the Paranaense Football Federation (FPF).

Anthropometric evaluation

Anthropometric variables analyzed were: age, weight, height, and four skinfolds: subscapular (SS), triceps (TS) medium axillary (MA) and calf (CA). The measurement of body weight, height and skinfold thickness were performed according to the Petroski[17] recommendations. To calculate the relative body fat (%BF) used the equation of Siri[18]: *{%GC = [495/Body density (g/ml)] – 450}*. Body density (Dens.) was calculated from the use of the regression model that uses the sum of four skinfold thickness proposed by Petroski[17]. *Dens. = 1,10726863 - 0,00081201 * (SS + TS + MA +CA) + 0,00000212 * (SS + TS + MA +CA)² - 0,00041761 * (Age)*. Petroski's[17] equation showed a strong correlation (R = 0.875) mesured adults Brazilian men By Hidrostatic Weighing with a standart error by 0.007.

To measure the height, we used a stadiometer with 0.1 cm extent. The total body weight was measured by an electronic scale Tanita (Model A-80), with precision of 100 g. The skinfold thickness was measured using a caliper Cescorf, accurate to 0.1 mm. The Body Mass Index (BMI) was calculated using the formula: weight (kg)/height² (m) and Lean Body Mass (LBM) = weight (kg) - mass fat (kg).

Aerobic fitness (VO_{2max})

To estimate the VO_{2max} was used the shuttle run test suggested by Léger[19]. This test estimates the VO_{2max} indirectly and is to running a distance of 20 meters between two lines, with the rhythm sound that determines the speed race. The initial test speed is 8.5 km/h, with a progressive increase of 0.5 km/h every minute. The test ends when the individual is no longer able to keep pace audible proposed successively accumulating two absences, and is then recorded the speed of the last stage completed. Where: y = VO_{2max} in mL/kg/min and X = speed in km/h (stage completed)

Soccer player performed the tests in same soccer field with using shoes and training uniform. The referees performed the test on a Athletics track, as indicated by FIFA.

Statistical analysis

The descriptive statistics was initially used to group the results in mean and standard deviation. Due to the small number of individuals in the groups analyzed, we adopted the logarithmic conversion for

variables not normalized according to the Gauss curve, so the use of parametric statistical parameters. We used the "t" test for independent samples to compare the referees with the players groups. Data were analyzed using SPSS version 11.0, adopting a significance level of 5%. The Effect Size was classified as negligible (<0.35), small (0.35 to 0.80), moderate (0.80 - 1.5) and large (> 1.5)[20].

Results

Table 1 and 2 shows the sample characteristics with the values of the mean and standard deviations by age, weight, height, BMI, LBM, %BF and VO_{2max} from Soccer players and referees, respectively. Statistical analysis comparing the anthropometric and physiological profiles by players and referees showed no statistically significant differences between the parameters: height, weight, BMI and LBM. However, there were statistically significant differences between age ($p \leq 0.001$), %BF ($p \leq 0.001$) and VO_{2max} ($p \leq 0.05$). The effect size and confidence interval, respectively: age: 0.16, -1.939 to 3.098; heigh: 0.45, -0.022 to 0.089; body mass: 0.41, -2.761 to 8.818; body mass index: 0.03, -1.280 to 1.393; %BF: 0.07, -1.424 to 2.219; lean body mass: 0.44, -2.011 to 7.272; VO_{2max}.: -1.88, -10.282 to -3.036.

Table 1. Anthropometric and Physiological characteristics by soccer players.

	Mean	Standart desviation	Max	Min
Age (years)	24,1	3,4	30	19
BM (kg)	78,0	8,3	93	60
Height (cm)	178,2	7,4	192	163
BMI (kg/m²)	24,5	1,9	28	21
% BF	10,8	2,6	19,2	7,6
LBM (kg)	69,5	6,6	81	54
VO_{2max}	56,7	5,8	63	42

BM: Body Mass; BMI: Body Mass Index; %BF: % Body Fat; LBM: Lean Body Mass; VO_{2max}. expressed in $mL.kg^{-1}.min^{-1}$

Table 2. Anthropometric and Physiological characteristics by soccer referees.

	Mean	Standart desviation	Max	Min
Age (years)	33,7	3,1	38	25
BM (kg)	82,8	12,8	87	72
Height (cm)	177,9	9,1	193,0	173,3
BMI (kg/m²)	24,9	4,5	27,4	23,3
% BF	15,5	3,7	18,7	12,1
LBM (kg)	70,0	10,9	75	60
VO_{2max}	50,0	4,3	52,4	44,5

BM: Body Mass; BMI: Body Mass Index; %BF: % Body Fat; LBM: Lean Body Mass; VO_{2max}. expressed in $mL.kg^{-1}.min^{-1}$

Discussion

The referees involved in this study are on average nine years older than the players. These data corroborate the claim that the elite referees are on average 10-15 years older than the players[21]. According to some studies, the fact that the referees are older than the elite soccer players, would imply a negative relationship between age and physical performance of referees[21]. The average age difference between players and referees can exist because the experience is considered among the International referees governing bodies, as *the Federation Internationale de Football Association* (FIFA) and the *Union European Football Association* (UEFA), for example, as prerequisite to entering the elite of the refereeing[22].

With respect to the fat percentage, it was observed that the referees had 15% versus 10% of the players. As the LBM was identical for all groups, when deducts the fat weight of the total weight, it is observed that the referees have five kilograms of fat more than the players. As this fat mass does not contribute to physical performance, it can be said that the referees run with a sort of five-kilograms backpack on his back during the game, which may contribute to the decline of physical performance during the game, as that superfluous weight burdens energetically any sporting activity. The center of discussion in sports, regarding the determination as to what would be the ideal combination of lean and fat mass, which contributes to the increase of physical performance in various sporting activities[23].

To Heyward and Stolarczyk[24], the anthropometric evaluation has great importance in the determination and guidance programs for weight control. Several studies have shown high correlation between the fat percentage and sports performance[25], showing up as postulated incompatibility between the best performance and high levels of subcutaneous adiposity.

In soccer there seems to be a consensus among researchers, the index ranging 7-12% of body fat (BF) as appointed being acceptable for soccer[26]. The players BF% identified in this study is similar to other studies conducted in Brazil. The BF% of 11.64 ± 1.61 was found in a study involving players of the Paraná State[27], the same state of the players in this study. In two studies involving paulistas players, mean values were found A BF% of 10.70 ± 1.40%[28] and 10.6%[29]. Players from other regions of America also showed BF% corroborate the data presented here, ie, 11.9 ± 1.7 BF% for Caribbean players[30] and 10.6 ± 2.6% was found in South America National Teams in Copa America[31].

The body fat percentage of soccer referees has not been defined, and the values and variation are much larger than the player of this sport, ie, the average is between 11-20%. The lower mean body fat percentage was reported in the scientific literature by Spanish referees (11.3 ± 2.15%)[17].

The fat percentage by Brazilian referees of São Paulo state was 13.50 ± 5.89%[32]. Referees Uruguayans had a average of 14.0 ± 2.4%[33] and the referees Chileans 15.4 ± 2.8%[34]. Brazilian referees by Rio Grande do Norte state, had a average of 16.5 ± 3.9%[15], this is similar to the Sergipe soccer referees, 16.4 ± 5.4%[35]. The elite referees of Paraná state, the same region of the referees of this study showed 19.3 ± 4.1 BF%[36]. This same study showed that younger referees have body fat percentages lower than more experienced referees. A study that aimed to determine the

referee's anthropometric profile throughout his career, showed that over 10 years the referees got on average 4 BF%[37].

These results suggest that more attention should be taken by committees in the referee's selection and, particularly, when they are organizing international competitions. Appropriate training strategies and nutrition should be recommended to the referees, in order to promote optimal health and physical performance[26]. Moreover, the persistent documentation by elite referees between 35-40 years old, and his amateur/semi-professional status, brings up questions about the overall health of this athletic population[38]. Additionally, physical fitness is strongly associated with the age progression, and particular attention should be given to the rules of this parameter.

The oxygen uptake measurement (VO_2), made by gas analyzers with higher levels of measurement accuracy, is what we call benchmark. However, reasons related mainly to the high cost of these devices, as well as the need for specialized personnel or trained in their handling and great time expenditure in use, the inappropriate in the study of large populations and are not a reality in many Brazilian soccer teams. The VO_{2max} estimation from protocols with submaximal or maximal features, which can be applied preferably on the soccer field has always attracted the attention of researchers in soccer and resulted in the creation and development of several tests, with characteristics of laboratory or field research, they require the use of sophisticated devices and provide reliable results when compared to those obtained by open circuit gas analyzers, for example: test 20 m Léger and Gadoury[19] and Yo-Yo endurance test I and II, Yo-Yo intermittent endurance I and II, Yo-Yo intermittent recovery I and II, both proposed by Bangsbo[39].

AOKI[40] states that in the literature it appears that the VO_{2max} of the players is about 55-60 ml/kg/min, similar to that found in the players involved in this study. However, numerous studies bring higher values of VO_{2max} for players. In a study in players of Paraná state, found the value of VO_{2max} 62.66 ± 2.64 mL.kg^{-1}.min^{-1}[27]. Others values were also reported in some players from German National Teams, the 1978, 62.0 ± 4.5 mL.kg^{-1}.min^{-1}[41], and 1981/82 (2nd place in the World Championship) were 59.5 ± 5.4 mL.kg^{-1}.min^{-1}[42], and 55.0 ± 3.2 mL.kg^{-1}.min^{-1} was recently reported to Caribbean soccer players[30].

The soccer player is constantly subjected to investigation of their VO_{2max} because this variable is important for finding potential aerobic as well be possible to verify this during the measurement variation of the athlete's anaerobic threshold as a result of physical training. However, this reality does not apply to soccer referee. FIFA, UEFA, the confederations or federations do not bother to apply physical tests that evaluate the aerobic power of the referees. Currently FIFA instituted to evaluate their referees a test consisting of 20x150 m sprint interspersed by a 50-m walk. By applying this test you can not find what referee is more physically prepared or have the best cardiorespiratory capacity[43]. Some studies have recently been developed alerting FIFA and UEFA about the poor correlation between this test and the activities performed by the referees during a match, necessitating the use a test that can be applied to officials with the aim of verifying the aerobic power and this test correlation with the motor actions of the referees developed in the course of the game[44].

The VO_{2max} of the referees, as did the players, is similar to the values obtained in the literature. In a study conducted in Paraná state where the study was carried, the average VO_{2max} was 52.2 ± 3.9 mL.kg^{-1}min^{-1} (data obtained from the Cooper test) officials of the Northeast of Brazil, the values were similar to this study, referees from Piaui by 49.2 ± 1.3 mL.kg^{-1}min^{-1}[45], Ceará 51.3 ± 2.5 mL.kg^{-1}min^{-1}[46] and from Sergipe 50.4 ± 2.0 mL.kg^{-1}min^{-1}[47].

Referees from other countries also showed similar values to this study. Using laboratory test, the referees Spaniards showed an VO_{2max} average of 54.9 ± 3.9 mL.kg^{-1}min^{-1}[14]. However, in a study of Danish referees described average VO_{2max} of 46.3 mL.kg^{-1}.min^{-1}[48]. Indeed, with a gas analyzer type K2[49], reported an average value of VO_{2max} of 49.30 ± 8.0 mL.kg^{-1}min^{-1} for eight referees that officiated in the Italian First Division. Later this same researches would publish another study involving two groups of the referees, young and older, this time found the VO_{2max} was 42.5 ± 4.4 mL.kg^{-1}.min^{-1} for referees with 42 years old, and 52.1 ± 7.4 mL.kg^{-1}.min^{-1} for referees with an average age of 33 years old[50]. In a more recent study showed that 10 Italian referees submitted a VO_{2max} of 51.8 ± 3.2 mL.kg^{-1}.min^{-1}, the VO_{2max} being determined in the laboratory using an open circuit system of telemetric K4[51].

The data showed that the referees have on average VO_{2max} ranging 45-55 mL.kg^{-1}.min^{-1}, whereas the player's variation is 55-65 mL.kg^{-1}.min^{-1}. Therefore, the aerobic capacity of the referees is less than the players. A limitation of this study is that it was not possible to diagnose what was the anaerobic threshold of referees and players, since according to the scientific literature, in a sporting activity such as football, the anaerobic threshold is very important, since an athlete that has a high VO_{2max} and a low anaerobic threshold can be considered untrained[52].

Conclusions

Through literature review for the reasoning of this study, it was established that the maximum oxygen uptake is one of the most studied variables in soccer. Several studies have demonstrated by measuring direct and indirect that this constitutes an essential variable to check if the athlete is able to perform this high level sport, as well as efforts to recover from short and intense characteristic of soccer. However, this is not a reality experienced by soccer referees, are evaluated by tests that do not measure any physiological variable, only serving to diagnose who is fit or not fit to referee competitive games by criteria set by FIFA.

The data showed that the referees have a VO_{2max} less than the players, so they could have impaired their physical performance during a match. Added to this, it appears that the umpires also have a high body fat percentage, ie, besides they have VO_{2max} that does not allow them to sustain an intensity physical activity such as those developed by a player, they also run during starting with a fat mass that weighs about 5 kilograms, which also contribute to the decline of physical performance.

Besides the referees are older than the players, these are not considered professional, having to engage in another profession on a daily basis and, as with increasing age there is a tendency for greater accumulation of body fat, it is suggested that the Federations, Confederations and the larger entity in the world, FIFA, offer their referees physical fitness programs associated with nutritional guidelines for improved athletic profile. In addition, the umpires undergo physical tests that can actually check the aerobic and anaerobic power, not the tests that serve merely

to consider them fit or unfit to officiating a soccer match, without any physiological parameter.

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