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Review article

A review of stature, body mass and maximal oxygen uptake profiles of U17, U20 and first division players in Brazilian soccer

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Abstract
Investigations in the physiological demands of soccer have identified that a significant percentage of energy production in match performance is provided through the aerobic pathways. It is therefore important to assess maximal oxygen uptake (VO_{2Max}) of players in order to evaluate their aerobic fitness status and optimize their physical conditioning. However, it is also important to consider the variation of (VO_{2Max}) profiles for soccer players, with differences having been identified in terms of playing position as well as playing style. This paper reviews the academic literature between 1996 and 2006 and reports on the methodologies employed and the values obtained for stature, body mass and (VO_{2Max}) profiles of soccer players of different positions in professional Brazilian clubs at U-17, U-20 and First Division levels. Indirect measurements accounted for the majority of tests conducted at U-17 (70%) and U-20 (84.6%) levels whereas at First Division level almost half of the (VO_{2Max}) evaluations were performed by direct measurements (47.8%). The mean (VO_{2Max}) profiles obtained for outfield players in U-17 was 56.95 ± 3.60 $ml·kg^{-1}·min^{-1}$, 58.13 ± 3.21 $ml·kg^{-1}·min^{-1}$ for U-20 players and 56.58 ± 5.03 $ml·kg^{-1}·min^{-1}$ for First Division players. In Brazil, the U-20 players appear to have highest VO_{2MAX} values, however the profiles reported for all outfield positions in U-17 and First Division levels are often lower than those reported for the same category of players from other countries. This may be a reflection of the style of play used in Brazilian soccer. This is further emphasized by the fact that the playing position with the highest VO_{2MAX} values was the external defenders whereas most findings from studies performed in European soccer indicate that midfielders require the highest VO_{2MAX} values.

Key words: Soccer, maximal oxygen uptake, playing positions.

Introduction

The exercise pattern of soccer can be described as dynamic, random and intermittent (Bloomfield et al., 2007) to an extent which makes physical conditioning of players a complex process. This pattern involves a myriad of physiological processes which act in random sequences throughout match-play and this provides a huge challenge for coaches to condition players for the specific requirements of the game. However, it has been established that in order to advance in playing level, players must develop their aerobic capacity to tolerate the physiological load at higher levels of play (Helgerud et al., 2001; Stølen et al. 2005; Wisløff et al., 1998). The total mean distance covered by the top-level players during match-play has been reported to be between approximately 10,000m to 13,500m with distinct differences observed between each playing position (Bangsbo et al., 2006; Barros et al., 2007; Di Salvo et al., 2007). Other researchers using sophisticated time-motion analysis techniques have suggested a higher mean distance of 13,746m for players in Champions League matches (Di Salvo et al., 2007). This could be otherwise represented as an exercise protocol of running ~150m every minute for 90mins, having a 15min rest period after the first 45mins. In order to achieve this, even at moderate intensity, a high demand is placed on the player's aerobic energy system. Also, when considering the anaerobic requirement for match-play, the necessity of a well developed aerobic system is vital in order to recover quickly between repeated bouts of high intensity anaerobic activity (Stølen et al. 2005). It is well documented that higher levels of aerobic fitness provides a player with greater involvement potential during a match (in European studies), with significant relationships reported between VO_{2MAX} and the total distance covered as well as the frequency of sprints made in a match (Bangsbo et al., 1991; Helgerud et al., 2001; Wisløff et al., 1998), with time spent in high intensity activity as well as the number of involvements with the ball by the player (Helgerud et al., 2001) and ultimately, the final classification of the team in competitions (Wisløff et al., 1998). These improvements in performance have been associated with a greater ability to offset fatigue through an enhanced oxidization of lipids as well as sparing of glycogen and lower lactate production (Henriksson & Hickner, 1996).

To establish a profile of the aerobic capacity of soccer players, it is critical to consider many different independent factors which include chronological age, biological maturity, training age, morphology and anthropometry as well as preferred playing position. In order to establish normative data, profiles should be categorized against a range of levels of performance, as it appears that higher performance levels require higher physical and physiological demands (Rienzi et al., 2000). In addition, the measurement process for aerobic capacity must be considered as many different protocols have been suggested which ultimately fall into two categories, namely direct evaluation through online gas analysis techniques under laboratory conditions or indirect protocols using field testing methods or ergometers such as treadmills. Finally, it is of extreme importance to recognize the time of season that the testing has been performed, the mental and physical state of the players, the conditioning regimen the players have been through and the immediate period

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leading up to the testing. Due to a myriad of these variables, a wide range of VO_{2MAX} and estimated total energy expenditure (Kcal) have been reported in the literature.

The aerobic capacity (VO_{2MAX}) represents the metabolic parameter that quantifies the maximal oxygen uptake of an individual and is an important performance indicator in soccer. Mean heart rate values for university level players in the first and second half have been converted to a VO_2 of 51.1 and 46.2 $ml{\cdot}kg^{-1}{\cdot}min^{-1}$ respectively (Bangsbo, 1994). However, it has been established that these values of VO_2 are unlikely to be a true reflection of aerobic energy requirements through the HR-VO_2 regression calculation and provide an overestimation of energy expenditure (Reilly, 1997). In general, for high level soccer players the reference values obtained from laboratories in peer-reviewed articles appear to range between 55 – 70 $ml{\cdot}kg^{-1}{\cdot}min^{-1}$ (Bangsbo et al., 1991; Casajús, 2001; Kemi et al., 2003; Stølen et al., 2005), with some individual values reported as superior to 73 $ml{\cdot}kg^{-1}{\cdot}min^{-1}$ (Silva et al., 1999). Also, direct VO_2 measurements from match-play have been measured although the method is limited due to the inhibition of full involvement in soccer performance due to the restrictions from the equipment needed (Kawakami et al., 1992; Reilly, 1997). Therefore, it is suggested that players should have VO_{2MAX} values superior to 60 $ml{\cdot}kg^{-1}{\cdot}min^{-1}$ in order to be competitive at the highest levels in soccer (Reilly et al., 2000), although it is important to note that this is not a limiting factor to successful performance. Determining VO_{2MAX} of soccer players is therefore useful when assessing talent, in selection of players, in the design of physical conditioning programmes, predicting and monitoring physical match performance. Therefore, establishing reference parameters in high performance can assist in making important informed decisions, particularly for the strength & conditioning staff at soccer clubs and National teams to manipulate physical training to optimize the regimes.

Several recent studies have reported data of VO_{2MAX} values from First Division soccer players of high level teams from the European soccer league (Casajús, 2001; Dupont et al., 2005; Edwards et al., 2003; Kemi et al., 2003;Wisløff et al., 1998). From these data, it appears that players have increased aerobic capacity in these European studies in recent years. There may be several reasons for this increase which may include a higher number of sport science and conditioning practitioners appointed in top-level European clubs performing sophisticated profiling, prescription and monitoring of training as well as the increased use of technologies to analyze and performance (Carling et al., 2008). However, the development of aerobic capacity of soccer players playing in Brazil has not been collated and reported which is surprising when considering the success of Brazilian National Teams in recent years in international competitions, including winning the FIFA World Cup in 1994 and 2002, the Copa America in 1997, 1999, 2004 and 2007 and the Confederations Cup in 2005. Thus, this present study aims to report on the stature, body mass and VO_{2MAX} profiles of Brazilian soccer players reported since 1996, draw some comparisons with other playing nations and provide contemporary data for players identified by age category and playing position, in particular to provide reference for coaches and practitioners in Brazil and in Europe, where many Brazilian players are signed to European clubs.

Methods

In order to track the physical and physiological development of Brazilian soccer players, a review of International and Brazilian sport science journal publications between 1996 and 2006 was undertaken. Inclusion categories for this study included each publication had to have been subjected to peer-review and contain the provision of data concerning the biographic, anthropometric and maximal oxygen uptake (VO_{2MAX}) values from high level male Brazilian soccer players in any of the First Division, U-17 (under 17 years old), U-20 (under 20 years old) categories and First Division State and National clubs. Internet sources where utilized to access electronic journal databases including *Medline, Scielo* and *SportDiscus* in order to identify and, where possible, access appropriate papers to be included in this review. Articles that were not available in an online format were accessed through a university library and in proceedings of congresses and scientific encounters. In particular, the methods of aerobic capacity assessments were compiled and reviewed as well as biographical data, body mass, stature and VO_{2MAX} data for the following positions: goalkeepers, central defenders, external defenders (also known in Europe as wing-backs or full-backs), midfielders and forwards.

Results

A total of 32 research papers involving 49 experimental studies were considered for this review. Each study provided data on playing level, number of subjects, measurement process and VO_{2MAX} values. Of these, 17 studies provided full details of age, body mass and stature and 15 studies provided full or partial details of these parameters. Only 7 of these studies provided full details of VO_{2MAX} values for the 5 positional categories and a further 7 studies provided details for only some of the positional categories. Tables 1 and 2 illustrate the full profile of studies according to the inclusion criteria and the values for U-17, U-20 and First Division players.

The anthropometric profiles for body mass and stature of soccer players in Brazil provide some clear comparisons with other values reported for a similar era. The U-17 players in Brazil were of similar stature to professional youth soccer players in the UK but appeared to have less body mass (Franks et al., 1999, McMillan et al., 2005). The Brazilian based studies reported a range of mean values of 173-177cm and 60-71kg for the U-17 group. The U-20 soccer players ranged from mean values between 174-181cm and 66-75.5kg which were similar values to those players of equivalent age reported for Tunisian players (Chamari et al., 2004) and Greek players Metaxas et al., 2005) as well as similar body mass, but inferior stature to Norwegian players (Helgerud et al., 2001).

Table 1. Biography, anthropometrical and maximal oxygen uptake (VO_{2MAX}) characteristics reported in literature between 1996 and 2006 for U-17 and U-20 categories from Brazilian soccer players. Data are means (±SD).

Source	Division	n	Age (yr)	BM (kg)	Stature (m)	Test	VO_{2MAX}	GK	External Def	Central Def	MF	FORW
U-17												
Lopes & Marins,1996	FN	24	-	67.5 (5.3)	1.73 (.03)	Maximum in TR	60.4 (3.2)	-	61.4 (.7)	57.6 (3.2)	59.6 (5.5)	62.9 (3.4)
Silva et al., 1997b	FN	19	16.9 (.6)	66.6 (6.2)	1.76 (.06)	Gas analysis in TR	66.0 (4.8)	-	-	-	-	-
Furtado & Silva, 1997	FN	27	15.8	64.2	1.74	Maximum in TR	54.1	-	-	-	-	-
Abrantes et al., 2000	FN	20	16.0	63.0 (4.4)	1.73 (.05)	12' Cooper (1982)	55.4 (2.7)	47.6	56.2 (2.0)	56.3 (1.3)	56.7 (1.8)	48.8 (.0)
Ley et al., 2002	FN	23	15.9 (.7)	65.5 (8.7)	-	Gas analysis in TR	55.3 (2.8)	-	-	-	-	-
Campeiz et al., 2004	FS	15	15.9 (.8)	67.1 (6.0)	175.0 (.04)	20m MSFT	49.5 (2.9)	-	-	-	-	-
Coelho, 2005	FN	26	16.4 (.5)	68.1 (4.2)	175.1 (.07)	Margaria (1963)	56.1 (2.0)	-	-	-	-	-
Driemeir et al., 2005	FS	16	-	61.5 (7.2)	174.0 (.06)	20m 20m MSFT	57.9 (4.8)	-	-	-	-	-
Driemeir et al., 2005	FS	16	-	60.9 (6.6)	1.74 (.06)	20m 20m MSFT	60.1 (4.9)	-	-	-	-	-
Azevedo et al., 2006	SS	9	16.1 (.8)	71.0 (6.8)	1.77 (.05)	Gas analysis in TR	54.7 (4.3)	-	-	-	-	--
U-20												
Furtado & Silva, 1997	FN	28	18.5	66.2	1.75	Maximum in TR	59.1	-	-	-	-	-
Silva et al., 1997b	FN	42	19.0 (.2)	71.3 (5.5)	1.77 (.06)	Gas analysis in TR	62.1 (6.1)	-	-	-	-	-
Gonçalves & Samulski, 1997	FN	57	18.5 (.9)	70.5	1.76	Maximum in TR	63.2 (3.6)	50.2	-	-	64.5	-
Ley et al., 2002	FN	12	18.2 (.7)	75.5 (6.1)	-	Gas analysis in TR	59.9 (2.2)	-	-	-	-	-
Pereira, 2003	FN	26	18.9 (1.2)	-	-	20m 20m MSFT	63.2 (3.8)	59.2 (4.3)	63.1 (2.3)	64.5 (2.3)	65.6 (3.7)	60.8 (.7)
Campeiz et al., 2004	FS	18	17.8 (.8)	70.1 (4.8)	1.77 (.04)	20m 20m MSFT	49.6 (2.9)	-	-	-	-	-
Campeiz et al., 2005	FS	13	18.0 (.9)	71.7 (5.2)	-	Yo Yo End Test	55.9 (3.6)	-	57.9 (3.6)	54.8 (3.2)	56.5 (2.8)	54.5 (3.2)
Campeiz et al., 2005	FS	13	-	-	-	Yo Yo End Test	57.6 (2.1)	-	59.0 (3.6)	58.2 (2.9)	58.2 (.6)	55.0 (1.3)
Coelho, 2005	FN	18	18.2 (.7)	70.3 (4.9)	1.78 (.09)	Margaria (1963)	59.2 (2.9)	-	-	-	-	-
Santos, 2005	FS	26	-	-	-	3600 m	51.7 (2.5)	55.9 (4.4)	-	53.1 (3.1)	50.5 (4.1)	51.6 (.2)
Silva & Minuzzi, 2006	FS	12	19.4 (.3)	72.9 (2.1)	1.81 (.02	20m 20m MSFT	58.6 (.8)	-	-	-	-	-
Petroni et al., 2006	FS	25	18.2 (2.3)	72.7 (3.5)	1. 74 (.09)	$V_{amax(5)}$	58.4 (5.0)	-	-	-	-	-
Braz et al., 2006	FS	14	18.6 (1.2)	71.2 (8.3)	1.80 (.07)	Yo Yo IT	57.1 (3.5)	-	-	-	-	-

BM = Body Mass; Maksimal oxygen uptake = VO_{2MAX} ($ml \cdot kg^{-1} \cdot min^{-1}$); GK = Goalkeepers; External Def = External defenders; Central Def = Central defenders; MF = Midfielders; FORW = Forwards; FN = First National; FS = First State; SS = Second State; TR = treadmill; MSFT = Multi-Stage Fitness Test; End Test = Endurance Test; IT = Intermittent Test.

The profiles of the First Division players in Brazil were similar in stature and body mass to players in Greece (Kalapotharakos et al., 2006) and Saudi Arabia (Al-Hazzaa et al., 2001). The ranges of mean values for these players were 173-181cm and 61-73kg. However, the players in Brazil were similar only in body mass with players of similar positions from Spain (Bloomfield et al., 2005, Casajús 2001), Germany (Bloomfield et al., 2005) Italy (Bloomfield et al., 2005, Mohr et al., 2003), Denmark (Krustrup et al., 2006, Krustrup et al. 2003, Mohr et al., 2003), Norway (Wisløff et al., 1998), England (Bloomfield et al., 2005) and were generally smaller in stature with equivalent players from these European countries. Table 3 illustrates biographical, anthropometric and performance characteristics of professional and elite soccer players for other Nations since 1995.

The majority of tests for the assessment of VO_{2MAX} for U-17 and U-20 categories were performed through indirect evaluation. For the U-17 players, the majority of protocols used were either the 20m Multi-Stage Fitness Test (MSFT), originally proposed by Leger et al. (1988), or forms of incremental running to maximum on a treadmill. There were only 3 studies that were conducted with online gas analysis to exhaustion on a treadmill (Azevedo et al., 2006; Ley et al., 2002; Silva et al., 1997b). The highest values reported for this age group were by Lopes and Marins (1996) who used a maximal effort

Table 2. Biography, anthropometrical and maximal oxygen uptake (VO_{2MAX}) characteristics reported in literature between 1996 and 2006 for First Division Brazilian soccer players. Data are means (±SD).

Source	Level	n	Age (yr)	BM (kg)	Stature (m)	Test	VO_{2MAX}	GK	External Def	Central Def	MF	FORW
Silveira Jr. et al. , 1996	NT1994	21	27.3 (3.7)	79.9	1.80	Gas analysis in TR	58.9	56.7 (3.1)	-	-	60.5 (3.6)	56.5 (2.4)
Barros et al., 1996	FN	77	-	-	-	Gas analysis in TR	56.2 (6.2)	54.0 (6.5)	59.9 (8.3)	55.5 (4.6)	55.9 (6.7)	56.0 (4.9)
Furtado & Silva, 1997	FN	20	23.7	73.6	1.75	Maximum in TR	56.5	-	-	-	-	-
Silva et al., 1997b	FN	27	24.2 (4.1)	74.9 (7.2)	1.79 (.06)	Gas analysis in TR	52.5 (7.5)	-	-	-	-	-
Silva et al., 1997a	FS	16	24.2 (3.6)	75.0 (8.0)	1.79 (.05)	Ellestad (1969) gas analysis in TR	50.0 (6.0)	-	-	-	-	-
Silva et al., 1997a	FS	16	24.6 (3.6)	74.0 (7.0)	1.79 (.05)	Ellestad (1969) gas analysis in TR	53.0 (5.0)	-	-	-	-	-
Mahseredjian et al., 1998	FN	15	24.6 (3.2)	75.7 (6.4)	1.78 (.05)	Gas analysis in TR	54.3 (3.2)	-	-	-	-	-
Mahseredjian et al., 1998	FN	15	24.6 (3.2)	75.4 (6.2)	1.78 (.05)	Gas analysis in TR	58.6 (3.6)	-	-	-	-	-
Silva et al., 1999	FN	18	24.0 (4.0)	72.5 (5.9)	1.77 (.07)	Gas analysis in TR	63.8 (4.9)	-	-	-	-	-
Teixeira et al., 1999	FN	23	24.8 (3.3)	72.8 (6.4)	1.79 (.05)	Gas analysis in TR	49.1 (4.8)	-	-	-	-	-
Silva et al., 2000	FN	26	24.0 (4.3)	73.0 (5.7)	1.77 (.06)	Gas analysis in TR	60.5 (4.7)	-	-	-	-	-
Silva & Barros, 2000	FS	11	-	79.9	1.80	Gas analysis in TR	58.9	56.7 (3.1)	-	-	60.5 (3.6)	56.5 (2.4)
Castro & Barros, 2000	FS	21	27.3 (3.7)	-	-	Gas analysis in TR	56.2 (6.2)	54.0 (6.5)	59.9 (8.3)	55.5 (4.6)	55.9 (6.7)	56.0 (4.9)
Ley et al. , 2002	FS	77	-	73.6	1.75	Maximum in TR	56.5	-	-	-	-	-
Balikian et al., 2002	SS	20	23.7	74.9 (7.2)	1.79 (.06)	Gas analysis in TR	52.5 (7.5)	-	-	-	-	-
Campeiz et al., 2004	FS	27	24.2 (4.1)	75.0 (8.0)	1.79 (.05)	Ellestad (1969) gas analysis in TR	50.0 (6.0)	-	-	-	-	-

NT 1994 = National team 1994 World Cup; BM = Body Mass; Maksimal oxygen uptake = VO_{2MAX} (ml·kg^{-1}·min^{-1}); GK = Goalkeepers; External Def = External defenders; Central Def = Central defenders; MF = Midfielders; FORW = Forwards; FN = First National; FS = First State; SS = Second State; TR = treadmill; MSFT = Multi-Stage Fitness Test; End Test = Endurance Test; IT = Intermittent Test.

on a treadmill to predict a VO_{2MAX} of 62.9 ± 3.37 ml·kg^{-1}·min^{-1} for forwards and 61.39 ± 0.65 ml·kg^{-1}·min^{-1} for external defenders. Silva et al., (1997b) also reported a value of 65.97 ± 4.81 ml·kg^{-1}·min^{-1} through gas analysis from a treadmill test in a group of 19 players aged approximately 17 years old but unfortunately did not indicate which positions these players played. Similarly, for the U-20 players, the most used protocol was also the MSFT, however, there has been a wider range of test protocols reported than at U-17 level. This includes maximum indirect protocols in treadmill, Yo-Yo Endurance Test (Bangsbo, 1994), Yo-Yo Intermittent Test (Krustrup, 2003), a 3600m Test, Margaria (Margaria, 1963) and a 5min running test known as $V_{amax(5)}$ (Berthon et al., 1997). Direct measurements occurred on only two occasions in this age category although one study contained 42 subjects but provided no coverage of positional differences (Silva et al., 1997b). The highest values reported were by Pereira (2003) who measured 26 First National Level players aged 18-19 using the MSFT and predicted an overall value of 63.23 ± 3.79 ml·kg^{-1}·min^{-1} with only small differences between the outfield positions with the midfielders reaching a predicted peak of 65.60 ± 3.67 ml·kg^{-1}·min^{-1}. In contrast, Campeiz et al., (2005) provided values below 60 ml·kg^{-1}·min^{-1} through use of the Yo-Yo Endurance Test in a group of 13 First State players aged approximately 18 years old. In this trial, external defenders reached the highest values of all the positions, although these players were of a lower playing standard to the other studies performed at this age level. It is also important to note that the Yo-Yo test is an assessment for intense intermittent exercise and requires high rates of aerobic and anaerobic energy turnover which may act as a limiting factor to determine accuracy in aerobic capacity evaluation.

At First Division level, a greater number of VO_{2MAX} assessments that have been reported in the scientific press were performed through direct measurement protocols compared to U-17 and U-20 groups. Of all VO_{2MAX} evaluation studies performed with this level, 47.83% used gas analysis techniques with the remaining studies used a wide range of indirect protocols similar to the U-20 group, including the MSFT and Yo-Yo Tests. The reported overall values were slightly lower than those reported in the U-20 group with gas analysis mean values higher than 60 ml·kg^{-1}·min^{-1} provided by Silva et al., (1999) and Silva et al., (2000) for 18 and 26 First National players respectively and Balikian et al. (2002) for 25 Second State players. The majority of remaining studies reported mean values between 50-57 ml·kg^{-1}·min^{-1}. The highest reported value for a positional group was 62.31 ± 0.86 ml·kg^{-1}·min^{-1} for external defenders within a group of 45 First National players, although the details of the methodology were not provided (Pavanelli et al., 2004).

Table 3. Mean (±SD) values for biographical, anthropometric and performance characteristics of professional and elite soccer players reported since 1995.

Source	Nationality	Level	n	Age (yr)	Stature (m)	BM (kg)	BMI* (kg·m^{-2})	Body Fat (%)	Somatotype	VO_{2max}	CMJ (cm)
Mercer et al., 1995	English	PROF D1	15	24.7 (3.8)	1.79 (.08)	77.6 (9.2)	24.22	16.2 (3.4)	-	62.6 (3.8)	44.8 (6.8)
Raastad et al., 1997	Norwegian	PROF	28	23.5 (3.0)	-	78.9 (7.8)	-	-	-	62.8 (4.1)	-
Bury et al., 1998	Belgium	PROF D1	15	24.2 (2.6)	1.81 (.05)	76.8 (5.2)	23.52	14.1 (1.1)	-	62.8 (4.0)	-
Di Salvo et al., 1998	Italian	PROF	44	17.8 (.6)	1.81 (.04)	72.6 (4.7)	22.09	-	-	-	-
Rico-Sanz, 1998	Puerto Rican	Olympic	8	17.0 (2.0)	1.70 (.07)	63.4 (3.1)	21.99	7.6 (3.1)	-	69.2	-
Rienzi et al., 1998	South American	PROF	110	26.1 (4.0)	1.77 (.06)	76.4 (7.0)	24.39	10.6 (2.6)	2.0-5.3-2.2	-	-
Wisløff et al., 1998	Norwegian	PROF D1	14	23.8 (3.8)	1.81 (.05)	76.9 (6.3)	23.45	-	-	67.6 (4.0)	56.7 (6.6)
Wisløff et al., 1998	Norwegian	PROF D1	15	23.8 (3.9)	1.81 (.05)	76.8 (7.4)	23.49	-	-	59.9 (4.1)	53.1 (4.0)
Rico-Sanz et al., 1999	Swiss	PROF	17	17.5 (1.0)	1.77 (.05)	69.4 (6.4)	22.08	-	-	-	-
Batterham et al., 1999	English	PROF PL	9	18.1 (.6)	1.81 (.06)	70.5 (5.0)	21.52	-	-	-	-
Mujika et al., 2000	Spanish	PROF	17	20.3 (1.4)	1.80 (.06)	74.8 (5.5)	23.11	7.9 (1.6)	-	-	47.4 (6.0)
Aziz et al., 2000	Singaporean	National	23	21.9 (3.6)	1.75 (.06)	65.6 (6.1)	21.42	-	-	58.2 (3.7)	-
Rienzi et al., 2000	South American	PROF	11	26.1 (4.0)	1.77 (.06)	76.4 (7.0)	24.39	10.6 (2.6)	2.2-5.4-2.2	-	-
Sözen et al., 2000	Turkish	PROF	83	25.5 (4.0)	1.78 (.06)	73.6 (8.5)	23.28	-	-	-	-
Al-Hazzaa et al., 2001	Saudi Arabian	PROF	154	25.2 (3.3)	1.77 (.06)	73.1 (6.8)	23.28	12.3 (2.7)	-	56.8 (4.8)	-
Casajus, 2001	Spanish	PROF	15	26.3 (3.1)	1.80 (.07)	78.5 (6.4)	24.23	8.2 (.91)	2.6-4.9-2.3	66.4 (7.6)	41.4 (2.7)
Cometti et al., 2001	French	PROF D1	29	26.1 (4.3)	1.80 (.04)	74.5 (6.2)	23.05	-	-	-	41.6 (4.2)
Cometti et al., 2001	French	PROF D2	32	23.2 (5.6)	1.78 (.06)	73.5 (14.7)	23.20	-	-	-	39.7 (5.6)
Helgerud et al., 2001	Norwegian	PROF D1	19	18.1 (.8)	1.81 (.06)	72.2 (11.1)	21.97	-	-	64.3 (3.9)	54.7 (3.8)
Craven et al., 2002	English	PROF D1	14	23	1.81 (.06)	80.1 (9.2)	24.45	-	-	-	-
Dowson et al., 2002	New Zealand	National	21	Senior	1.78 (.07)	78.9 (6.0)	24.90	17.4	-	60.5 (2.6)	48.0 (4.6)
Strudwick et al., 2002	English	PROF PL	19	22.0 (2.0)	1.77 (.06)	77.9 (8.9)	24.87	12.3 (2.9)	-	59.4 (6.2)	-
Carvalho et al., 2003	Portuguese	PROF D1	74	-	1.77 (.06)	76.7 (5.5)	24.51	-	-	-	-
	Portuguese	PPOF GK	9	-	1.83 (.03)	81.5 (8.0)	24.34	-	-	-	34.2 (8.4)
	Portuguese	PROF CEN Def	13	-	1.85 (.06)	82.0 (6.2)	24.06	-	-	-	32.1 (7.3)
	Portuguese	PROF Full-Back	9	-	1.73 (.05)	69.9 (6.4)	23.36	-	-	-	32.4 (2.9)
	Portuguese	PROF CEN MF	17	-	1.76 (.08)	74.3 (7.0)	23.96	-	-	-	35.5 (6.2)
	Portuguese	PROF Wide MF	15	-	1.75 (.05)	75.3 (4.8)	24.48	-	-	-	38.8 (9.0)
	Portuguese	PROF Strikers	11	-	1.80 (1.1)	78.9 (8.6)	24.35	-	-	-	35.3 (5.2)
Matkovic et al., 2003	Croatian	National	57	23.2 (3.5)	1.81 (.06)	77.6 (5.7)	23.79	14.9 (3.5)	-	-	-
	Croatian	National GK	7	-	1.83 (.04)	80.1 (5.1)	23.94	20.2	-	-	-
	Croatian	National Def	17	-	1.82 (.05)	-	-	13.9	-	-	-
	Croatian	National MF	21	-	1.81 (.06)	-	-	14.4	-	-	-
	Croatian	National FORW	12	-	1.79 (.06)	-	-	-	-	-	-
Wilson et al., 2004	Northern Irish	PROF	34	26.0 (5.8)	1.73 (.08)	76.2 (5.1)	25.46	-	-	-	-
	Northern Irish	PROF Def	12	26.5 (6.2)	1.75 (.01)	77.6 (5.1)	25.34	15.6 (2.9)	-	49.9 (5.4)	42.8 (7.1)
	Northern Irish	PROF MF	10	26.7 (6.1)	1.75 (.01)	76.6 (4.8)	25.01	16.0 (2.2)	-	51.6 (7.8)	47.0 (9.6)
	Northern Irish	PROF Striker	12	24.9 (5.5)	1.71 (.01)	74.5 (5.2)	25.48	14.3 (2.2)	-	53.1 (5.4)	48.3 (10.0)

BM = Body Mass; BMI = Body Mass Index; Maximal oxygen uptake = VO_{2MAX} (ml·kg^{-1}·min^{-1}); CMJ = Counter Movement Jump PROF = Professional; GK = Goalkeepers; CEN = Central, Def = defenders; MF = Midfielders; FORW = Forwards. * BMI based on mean values of stature and body mass.

Discussion

In Brazil, a country with more than 180 million inhabitants, soccer is regarded as the national sport with a reported more than 30 million recreational players and 12,000 players with professional registrations in clubs all over the world (CBF, 2008). At an elite level, there however appears to be distinct physical and physiological differences between Brazilian players and their European counterparts. In this respect, it appears that although players in Brazil are shorter in stature, they are similar in body mass. In addition, the talent selection process in Brazil is regarded as different to Europe due the Brazilian style of play which prioritizes player selection through the technical aspects of the game rather than recruiting through physical size (Drubsky, 2003, p. 187). In contrast, the stature and body mass of players has been suggested to be an important policy for player recruitment in major European Leagues (England, Italy, Spain, Germany) in order to suit the style of the play and the specific physical demands of each playing position (Bloomfield et al., 2005). In this respect, the top leagues in Spain and Italy had a much higher number of players from South America and on average, shorter and lighter players compared to those in England and Germany, particularly in midfield and forward positions (Bloomfield et al., 2005). These authors also postulated that this phenomenon could additionally be attributed to cultural and climatic reasons for adaptation to lifestyle in a European country when migrating from South America, rather than simply for the style of play adapted by teams in these respective leagues. Of course, other criteria for success include tactical awareness, teamwork abilities, fitness and psychological variables.

Interestingly, although clear trends exist in terms of age, stature and body mass for different positions in different countries, physical size and shape is not necessarily a priority predictor for success (Reilly et al., 2000). There are also a wide range of physiological values reported for players of different levels in different countries. One possible reason for these differences is a lack of consistency or uniformity in testing protocols to assess VO_{2MAX}. This not only relates to the wide choice of possible tests to implement but also the variety in fitness status of the players, the stage of the season when they are tested, the preparation of the players prior to testing, their motivation, the testing arena itself as well as the environmental conditions. Furthermore, due to the high volume of games per season in most countries, it can be very difficult to schedule appropriate testing occasions. All these factors may influence the outcome of the tests and some or all of this information is often not reported in the articles reviewed in this study, particularly in assessments of indirect measurements. This can therefore make it difficult to make true comparisons between studies and only assumptions should be made when assessing any differences. Furthermore, it is important to recognize that a high VO_{2MAX} value is not the sole predictor of high aerobic performance in soccer, as this is dependent of two other important elements, namely anaerobic threshold and running economy (Bunc et al., 1987; Chamari et al., 2005; Edwards et al., 2003; Helgerud et al., 2001; Kemi et al., 2003). The VO_{2MAX} assessment also possesses some limitations, particularly in the interpretation of results based upon $ml.kg^{-1}.min^{-1}$ as the valid oxygen consumption necessary for an intermittent running pattern as in soccer does not rise in direct proportion to body mass (Wisløff et al., 1998). This results in players with lower body mass having an overestimated VO_{2MAX} value and the heaviest players to having an underestimation in real work capacity terms (McMillan et al., 2005). It is therefore important to factor a correction for body mass ($ml \cdot kg^{-0.75} \cdot min^{-1}$) to make direct comparisons between players of different body mass (Wisløff et al., 1998; Al-Hazzaa et al., 2001; McMillan et al., 2005). Furthermore, there should be some caution in using VO_{2MAX} testing for direct soccer performance assessment, which usually involves an incremental protocol of increasing speeds on a treadmill at set time intervals. As soccer involves an exercise pattern taxing both the aerobic and anaerobic energy pathways in random and intermittent intervals, using dynamic movement patterns (Bloomfield et al., 2007) players are conditioned specifically for this activity pattern and are not ideally prepared for the VO_{2MAX} assessment protocol. Although it is suggested that players should have VO_{2MAX} values superior to 60 $ml \cdot kg^{-1} \cdot min^{-1}$ in order to be competitive at the highest levels in soccer (Reilly et al., 2000), some of the top players would be expected to have superior values in anaerobic components, often to the detriment of their aerobic capacity, therefore VO_{2MAX} values must be viewed alongside speed, agility and power values for a more appropriate assessment (Stølen et al. 2005; Wisløff et al., 1998).

In addition, one of the main limitations for the majority (70.7%) of Brazilian soccer studies is that they even lack detail on the breakdown for different positions and only 15.7% of the studies provide complete data for different playing positions. The absence of this information makes it difficult to characterize and create a more detailed profile of the Brazilian soccer players' aerobic fitness in their different positions as well as different training periods. It has been suggested that at an elite level, an improvement between 3% and 10% should be expected from a physical conditioning period of 4 to 15 weeks during the season (Bangsbo, 1994; Helgerud et al., 2001; Silva et al., 1997a). This highlights the importance of testing through the season, so that a thorough evaluation can occur and training programmes can be adjusted at critical moments of the season.

Overall, the results of VO_{2MAX} in studies relating to Brazilian soccer players suggest that they possess lower levels of aerobic power than players from other countries, particularly in Europe. This may be due to a series of factors, including the total training time dedicated for development of aerobic capacity, the different training regimens; or even a lower innate aerobic capacity, but mainly it may be suggested it is due a different style of play and subsequently a different physical demand needed for Brazilian soccer. This difference was highlighted by Rienzi et al. (2000) who reported a mean total distance of

8,638 ± 1,158m covered by players in the Copa América, was significantly lower ($p < 0.05$) than the mean total distance covered by players from the English Premier League 10,104 ± 703m. There were also a higher number of passes made in Brazilian soccer and a less direct style of play identified which could relate to the lower levels of aerobic power also reported between these groups of players and was also a similar finding to that reported by Barros et al. (1998) of 7,490 ± 775m for a Brazilian First Division team. However, other studies have found similar distances in Brazilian soccer to European studies including Ananias et al. (1998) who found superior total distance covered by a small number of Brazilian players (n = 6) from First Team soccer (2 central defenders, 2 midfielders and 2 forwards) where the first half mean distance of 5,446 ± 550m was significantly higher ($p < 0.05$) than the second half mean distance of 4,945 ± 366m and a mean total distance covered of 10,392 ± 849m, a value similar to those found by studies with First Division players from other countries (Bangsbo et al., 2006; Di Salvo et al., 2007; Mohr et al., 2003; Santos et al., 2001). Recently, Barros et al. (2007) also found a similar mean total distance covered in comparison with European soccer of 10,012 ± 1,024m for a larger group of Brazilian First Division players (n = 55) evaluated in 55 games over the course of three seasons between 2001-2004. This may suggest either a change in playing style, pitch size, playing environment, or in fitness capacity in Brazilian players. One possible reason for this potential change could be for Brazilian players to be spotted by European talent scouts on the basis on a player's suitability to compete in the respective leagues and therefore migrate to the more financially lucrative European clubs. However, it should also be noted that methodological differences in assessing work-rate may also account for some of the observed differences between various studies.

Within Brazilian soccer, it appears that from the ages of 17-20 there is an important period of physical development emphasized for preparation for performance at First Division Level. This physical development phase is attributed to a higher volume of intense training performed by players at U-20 level in comparison to U-17 and even First Division (Drubsky, 2003, p. 177). The training includes formal (coached) speed, strength and aerobic power development as well as superior tactical knowledge of the Brazilian style of play, although this development is built on a solid foundation of sound execution of the technical aspects of the game which have been developed up to and beyond U-17 level (Drubsky, 2003, p. 174). However, as the data reported in the literature are often mean values, it would be useful for more of these studies to also have reported the peak values to understand the optimal profile of physical fitness for soccer players in Brazil. Of all the studies reviewed, only 3 provided any peak or range values. These were all in studies of First Division players, all from direct measurements, with individual peak VO_{2MAX} values reported at 73.21 $ml \cdot kg^{-1} \cdot min^{-1}$ (Silva, 1999), 58.6$ml.kg^{-1}.min^{-1}$ (Teixeira, 1999) and 69.8 $ml \cdot kg^{-1} \cdot min^{-1}$ (Silva, 2000) although positional specificity was not supplied. These values would provide conditioning coaches with a much better framework to establish ideal profiles for players of different ages in different positions, and perhaps also the profile of soccer-specific fitness variables at different stages of the season.

It is also important to recognize early in the specific physical development phase which the optimal playing position is for the young player (Gil et al., 2007). It is well understood that different playing positions require superior fitness variables for soccer than other playing positions (Balikian et al., 2002; Stølen et al., 2005; Wisløff et al., 1998). Therefore, identifying each player's specialized position is especially important in order to optimize their physical, physiological, psychological, technical and tactical development so that to prepare them for higher playing levels later in their career. It has been suggested that this should occur as young as 12 to 14 years old (Gil et al., 2007; Strøyer et al., 2004). In Brazil, there exists no governmental policy to provide soccer development in schools and physical education provision is generic to all sports. Furthermore, it appears that 'street soccer' is becoming less practiced and young players are increasingly being taught soccer in specialized soccer schools and clubs. From this system, talented players from 10 years old begin to play more systematically, integrating into the playing style of the club, yet with an emphasis placed on skill development (Drubsky, 2003, p. 147).

In terms of aerobic power, it is common to see the midfield players possessing the highest VO_{2MAX} values in the team, however it is evident that in studies of Brazilian soccer players, the highest values are held by the external defenders although they are only slightly higher than the midfielders. A possible reason for this is in the tactical system incorporated by Brazilian teams. A 4-4-2 playing system is frequently employed and the external defenders are expected to also contribute to attacking play on top of their defensive duties. This may be a characteristic of Brazilian soccer as no differences were found between total distance covered by the First Division external defenders and midfielders in Brazil (Barros et al., 1998; Barros et al. 2007). On the contrary, some studies on European soccer found significantly higher distances covered by midfielders ($p < 0.05$) than the other positions (Di Salvo et al., 2007; Bangsbo, 1994; Bangsbo et al., 1991), as well as distance covered at high intensity speeds ($p < 0.05$) (Di Salvo et al., 2007). Furthermore, the high VO_{2MAX} values in this position may also reflect the training effects from the match-play in competition as well as in training, in addition to the organised conditioning performed by these players.

Conclusion

There appear to be physical and physiological differences between Brazilian soccer and European soccer in terms of the anthropometric values and VO_{2MAX} profiles of players. In Brazil, there seems to be a development phase for players at U-20 level which prepares them for the demands at First Division level. VO_{2MAX} assessments have been performed by a wide range of test protocols with more sophisticated methods used with players at higher playing levels, however, different positional data and methodological information have been lacked consistency making it difficult to make sound comparisons between studies.

For coaches and physical trainers, special attention should perhaps be provided to improving the VO_{2MAX} values for Brazilian players which could provide the players with an even greater ability to become more involved in the match as well as increasing further their chances of securing a transfer to a financially lucrative European club.

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References

Abrantes, V., Moraes, M., Farias, P., Dortas, A. and Baqueiro, M. (2000) Perfil de aptidão física, dimensões fisiológicas e morfológicas da equipe juvenil 4° colocada no mundial Copa Nike de Futebol. *XXIII Simpósio Internacional de Ciências do Esporte, Octubre 05-08, São Caetano, São Paulo-Brazil.* Book of Abstract. 75.

Al-Hazzaa, H.M., Almuzaini, K.S., Al-Refaee, S.A., Sulaiman, M.A., Dafterdar, M.Y., Al-Ghamedi, A. and Al-Khuraiji, K.N. (2001) Aerobic and anaerobic power characteristics of Saudi elite soccer players. *The Journal of Sports Medicine and Physical Fitness* **41(1)**, 54-61.

Ananias, G.E.O., Kokobum, E., Molina, R., Silva, P.R.S. and Cordeiro, J.R. (1998) Capacidade funcional, desempenho e solicitação metabólica em futebolistas profissionais durante situação real de jogo monitorado por análise cinematográfica. *Revista Brasileira de Medicina do Esporte* **4(3)**, 87-95.

Azevedo, P.H.S.M., Marques, A.T., Oliveira, G., Oliveira, J.C., Perez, S., Nunes, J.E.D. and Bürger-Mendonça, M. (2006) Comparação das variáveis ventilatórias entre jogadores juvenis de futebol brasileiros e coreanos. *XXIX Simpósio Internacional de Ciências do Esporte, Octubre 05-07, São Caetano, São Paulo-Brazil.* Book of Abstract. 290.

Aziz, A.R., Chia, M. and The, K.A. (2000) The relationship between maximal oxygen uptake and repeated sprint performance indices in field hockey and soccer players. *Journal of Sports Medicine and Physical Fitness* **40**, 195 - 200.

Balikian, P., Lourenção, A., Ribeiro, L.F.P., Festuccia, W.T.L. and Neiva, C.M. (2002) Consumo máximo de oxigênio e limiar anaeróbio de jogadores de futebol: comparação entre as diferentes posições. *Revista Brasileira de Medicina do Esporte* **8(2)**, 32-36.

Bangsbo, J. (1994) The physiology of soccer with special reference to intense intermittent exercise. *Acta Physiologica Scandinavia* **151(619)**, 1-156.

Bangsbo, J., Nørregeard, L. and Thørso, F. (1991) Activity profile of competition soccer. *Canadian Journal of Sports Sciences* **16(2)**, 110-116.

Bangsbo, J., Mohr, M. and Krustrup, P. (2006) Physical and metabolic demands of training and match-play in the elite football player. *Journal Sports Science* **24(7)**, 665–674.

Barros, T.L., Lotufo, R.F. and Mine, F. (1996) Consumo máximo de oxigênio em jogadores de futebol. *Revista Treinamento Desportivo* **1(1)**, 24-26.

Barros, T.L., Valquer, W., Sant'anna, M. and Barbosa, A.R. (1998) Motion patterns of Brazilian professional soccer players. *Medicine and Science in Sport and Exercise* **30(5)**, S31-S174.

Barros, R.M.L., Misuta, M.S., Menezes, R.P., Figueroa, P.J., Moura, F.A., Cunha, S.A., Anido, R. and Leite, N.J. (2007) Analysis of the distances covered by First Division Brazilian soccer players obtained with an automatic tracking method. *Journal of Sports Science and Medicine* **6**, 233-242.

Batterham, A. M., Vanderburgh, P.M., Mahar, M.T. and Jackson, A.S. (1999). Modeling the influence of body size on $V0_2$ peak: effects of model choice and body composition. *Journal of Applied Physiology* **87(4)**, 1317 - 1325.

Berthon, P., Fellmann, N., Bedu, M., Beaune, B., Dabonneville, M., Coudert, J. and Chamoux, A. (1997) A 5-min running field test as a measurement of maximal aerobic velocity. *European Journal of Applied Physiology* **75**, 233-238.

Braz, T.V., Souza, E., Dallemole, C. Diniz, E., Domingos, M.M, Silva Jr., A.J. and Carvalho, T.B. (2006) Análise comparativa entre futebolistas juniores e profissionais: estudo a partir das capacidades físicas. *XXIX Simpósio Internacional de Ciências do Esporte, Octubre 05-07, São Caetano, São Paulo-Brazil.* Book of Abstract. 300.

Bloomfield, J., Polman, R.C.J., Butterly, R. and O'Donoghue, P.G. (2005) An analysis of quality and body composition of four European soccer leagues. *Journal of Sports Medicine and Physical Fitness* **45**, 58-67.

Bloomfield, J., Polman, R. and O'Donoghue, P. (2007) Physical demands of different positions in FA Premier League soccer. *Journal of Sports Science and Medicine* **6**, 63-70.

Bunc, V., Heller, J., Leso, J., Sprynarová, S. and Zdanowicz, R. (1987) Ventilatory threshold in various groups of highly trained athletes. *International Journal of Sports Medicine* **8**, 275-280.

Burgess, D.J., Naughton, G. and Norton, K.I. (2006) Profile of movement demands of national football players in Australia. *Journal of Science and Medicine in Sport* **9,** 334-341.

Bury, T., R. Marechal, P. Mahieu and F. Pirnay (1998) Immunological status of competitive football players during the training season. *International Journal of Sports Medicine.* **19(5)**, 364 - 368.

Campeiz, J.M., Oliveira, P.R. and Maia, G.B.M. (2004) Análise de variáveis aeróbicas e antropométricas de futebolistas profissionais, juniores e juvenis. *Revista Conexões* **2(1)**, 1-19.

Campeiz, V.P., Campeiz, J.M., Nunes, R., Campeiz, E.C.F.S. and Oliveira, R.F. (2005) Variação do consumo máximo de oxigênio de futebolistas sub-20 de diferentes posições táticas através de teste específico. I Congresso de Ciência do Desporto, December 01-03, Campinas,SP-Brazil. Book of Abstracts, 27.

Carling, C., Bloomfield, J., Nelson, L., and Reilly, T. (2008) The role of motion analysis in elite soccer: Contemporary performance measurement techniques and work-rate data. *Sports Medicine,* in press.

Carvalho, C., Roriz-de-Oliveira, P. and Carvalho, A. (2003) Analysis of different parameters of physical condition for footballers in accordance to their field position. World Congress of Science and Football V. Faculdade de Motricidade Humana, Universidade Técnica de Lisboa, Lisbon, Portugal., 282 - 283.

Casajús, J. A. (2001) Seasonal variation in fitness variables in professional soccer players. *Journal of Sports Medicine and Physical Fitness* **41**, 463-469.

Castro, J.W.B. and Barros, S.A. (2000) Gordura corporal x aptidão cardiorrespiratória no futebol de campo profissional. *XXIII Simpósio Internacional de Ciências do Esporte, Octubre 05-08, São Caetano, São Paulo-Brazil.* Book of Abstract. 75. In Portuguese.

CBF: Confederação Brasileira de Futebol [Internet]. cited 2008 Jan 22. Available from URL: http://cbfnews.uol.com.br/

Chamari, K., Hachana, Y., Ahmed, Y.B., Galy, O., Sghaïer, F., Chatard, J.C., Hue, O. and Wisløff, U. (2004) Field and laboratory testing in young elite soccer players. *British Journal of Sports Medicine* **38,** 191-196.

Chamari, K., Moussa-Chamari, I., Boussaidi, L., Hachana, Y., Kaouech, F. and Wisløff, U. (2005) Appropriate interpretation of aerobic capacity: allometric scaling in adult and young soccer players. *British Journal of Sports Medicine* **39**, 97-101.

Coelho, D.B. (2005) *Determinação da intensidade relativa de esforço de jogadores de futebol de campo durante jogos oficiais, usando como parâmetro as medidas de freqüência cardíaca*. Master's degree tesis, Universidade Federal de Minas Gerais, Brazil. 1-114. (In Portuguese: English abstract).

Cometti, G., Maffiuletti, N.A., Pousson, M., Chatard, J.C. and Maffulli, N. (2001) Isokinetic strength and anaerobic power of elite, subelite and amateur French soccer players. *International Journal of Sports Medicine* **22(1)**, 45-51.

Craven, R., Butler, M., Dickinson, L., Kinch, R. and Ramsbottom, R. (2002) Dietary analysis of a group of English first division players. In: *Science and football IV.* Eds: Spinks, W., Reilly, T. and Murphy, A. London, Routledge. pp. 230 - 233.

Di Salvo, V., Baron, R., Tschan, H., Calderon Montero, F.J., Bachl, N. and Pigozzi, F. (2007) Performance characteristics according to playing position in elite soccer. *International Journal of Sports Medicine* **28**, 222-227.

Di Salvo, V. and F. Pigozzi (1998) Physical training of football players based on their positional roles in the team. *Journal of Sports Medicine and Physical Fitness* **38(4)**, 294 - 297.

Dowson, M.N., Cronin, J.B. and Presland, J.D. (2002) Anthropometric and physiological differences between gender and age groups of New Zealand National soccer players. In: *Science and football IV*. Eds: Spinks, W., Reilly, T. and Murphy, A. London, Routledge. pp. 63 -71.

Driemeir, R.G., Mazzuco, M.A. and Silva, S.G. (2005) Respostas fisiológicas do treinamento de pré-temporada em futebolistas da categoria juvenil. *XXVIII Simpósio Internacional de Ciências do Esporte, Octubre 13-15, São Caetano, São Paulo-Brazil.* Book of Abstract. 176. In Portuguese.

Drubsky, R. (2003) *O universo tático do futebol: escola brasileira.* Health, Belo Horizonte. In Portuguese.

Duca, G.F.D., Correa, L.Q., Rodrigues, R.E.S., Betemps, F.M., Kalb, A.C., Ribeiro, P.A.B. and Rombaldi, A.J. (2005) Análise descritiva de aspectos antropométricos e funcionais de uma equipe de futebol de campo do campeonato gaúcho. *XXVIII Simpósio Internacional de Ciências do Esporte, Octubre 13-15, São Caetano, São Paulo-Brazil.* Book of Abstract. 88. In Portuguese.

Dupont, G., Millet, G.P., Guinhouya, C. and Berthoin, S. (2005) Relationship between oxygen uptake kinetics and performance in repeated running sprints. *European Journal of Applied Physiology* **95**, 27-34.

Edwards, A.M., Clark, N. and Macfadyen, A.M. (2003) Lactate and ventilatory thresholds reflect the training status of professional soccer players where maximum aerobic power is unchanged. *Journal of Sports Science and Medicine* **2**, 23-29.

Folly, D., Dantas, P. and Gomes, A.L.M. (2004) Características de força, VO_{2MAX} e somatotipia em jogadores de futebol de campo. *XXVII Simpósio Internacional de Ciências do Esporte, Octubre 07-09, São Caetano, São Paulo-Brazil.* Book of Abstract. 298. In Portuguese.

Franks, A.M., Williams, A.M., Reilly, T. and Nevill, A. (1999). Talent identication in elite youth soccer players: physical and physiological characteristics. *Journal of Sports Sciences* **17**, 812.

Furtado, E.S. and Silva, L.P.S. (1997) Descrição das variáveis Morfofuncionais das equipes juvenil, júnior e profissional de futebol. *Arthus Revista de Educação Física e Desportos* **13(1)**, 129-130. In Portuguese.

Gil, S., Ruiz, F., Irazusta, A., Gil, J. and Irazusta, J. (2007) Selection of young soccer players in terms of anthropometric and physiological factors. *Journal of Sports Medicine and Physical Fitness* **47**, 25-32.

Gonçalves, G.A. and Samulski, D. (1997) Comparação do VO_{2MAX} estimado, tempo de corrida de 50 metros e carga psíquica de jogadores de futebol de posições diferentes, de equipes da categoria júnior, da região metropolitana de Belo Horizonte – Minas Gerais. *Revista Brasileira de Ciências do Esporte* **18**, 174-179. In Portuguese.

Henriksson, J. and Hickner, R.C. (1996) Skeletal muscle adaptation to endurance training. In: *Intermittent high intensity exercise.* Eds: MacLeod, D.A.D, Maughan, R.J. Williams, C., Madeley, C.R., Sharp, J.C.M. and Nutton, R.W. E&FN Spon, London. 5-26.

Helgerud, J., Engen, L.C., Wisløff, U. and Hoff, J. (2001) Aerobic endurance training improves soccer performance. *Medicine and Science in Sport and Exercise* **33**, 1925-1931.

Kawakami, Y., Nozaki, D., Matsuo, A. and Fukunaga, T. (1992) Reliability of measurement of oxygen uptake by a portable telemetric system. *European Journal of Applied Physiology* **65(5),** 409-414.

Kalapotharakos, V.I., Strimpakos, N., Vithoulka, I., Karvounidis, C., Diamantopoulos, K. and Kapreli, E. (2006) Physiological characteristics of elite professional soccer teams of different ranking. *Journal of Sports Medicine and Physical Fitness* **46**, 515-519.

Kemi, O.J., Hoff, J., Engen, L.C., Helgerud, J. and Wisløff, U. (2003) Soccer specific testing of maximal oxygen uptake. *Journal of Sports Medicine and Physical Fitness* **43**, 139-144.

Krustrup, P., Mohr, M., Amstrup, T., Rysgaard, T., Johansen, J., Steensberg, A., Pedersen, P.K. and Bangsbo, J. (2003) The Yo-Yo intermittent recovery test: Physiological response, reliability and validity. *Medicine and Science in Sport and Exercise* **35(4)**, 697-705.

Krustrup P, Mohr M, Steensberg A, Bencke J, Kjær M, Bangsbo J. (2006) Muscle and blood metabolites during a soccer game: implications for sprint performance. *Medicine and Science in Sport and Exercise* **38(6),** 1165-1174.

Krustrup, P., Mohr, M., Nybo, L., Jensen, J.M., Nielsen, J.J. and Bangsbo, J. (2006) The Yo-Yo IR2 Test: physiological response, reliability, and application to elite soccer. *Medicine and Science in Sport and Exercise* **38(9)**, 1666-1673.

Leger, L.A., Mercier, M., Gadoury, C. and Lambert, J. (1988) The multistage 20 metre shuttle run test for aerobic fitness. *Journal of Sports Science*. **6**, 93-101

Ley, O.R., Gomes, A.C., Meira, A.L.J., Erichen, A.O. and Silva, S.G. (2002) Estudo comparativo dos aspectos funcionais e da composição corporal entre atletas de futebol de diferentes categorias. *Revista Brasileira de Fisiologia do Exercício* **1(1)**, 75-87. In Portuguese.

Lopes, A. and Marins, J.C.B. (1996) Características da aptidão física de jogadores de uma equipe de futebol da categoria juvenil/MG. *Revista Mineira de Educação Física* **4(2)**, 73. In Portuguese.

McMillan, K., Helgerud, J., Macdonald, R. and Hoff, J. (2005) Physiological adaptations to soccer specific endurance training in professional youth soccer players. *British Journal of Sports Medicine* **39(5)**, 273-7.

Mahseredjian, F, Cruz, W., Barbosa, A., Rosan, L.A., Cunha, M.A., Taira, A. and Merduço Filho, J.R.D. (1998) Análise da evolução dos índices de avaliação funcional em jogadores de futebol profissionais. *XXI Simpósio Internacional de Ciências do Esporte, Octubre 08-11, São Caetano, São Paulo-Brazil.* Book of Abstract. 69. In Portuguese.

Mahseredjian, F., Tebexreni, A.S., Valquer, W., Rocha, S. and Barros, T.L. (2003) Field testes as predictors of VO_{2MAX} and anaerobic threshold: in young soccer players. *Medicine and Science in Sport and Exercise* **35(suppl 5)**, 114.

Margaria, R., Cerretelli, P., Aghemo, P. and Sassi, G. (1963) Energy cost of running. *Journal of Applied Physiology* **18**, 367-370.

Matkovic, B. R., B. Matkovic, S. Jankovic, L. Ruzic and G. Leko (2003) Morphological characteristics of elite Croatian soccer players according to their position. In: *World Congress of Science and Football V, Faculdade de Motricidade Humana, Universidade Técnica de Lisboa, Lisbon, Portugal*. 172 - 173..

Mercer, T. H., Gleeson, N.P. and Mitchell, J. (1995) Fitness profiles of professional soccer players before and after pre-season conditioning. *Journal of Sports Sciences* **13(6)**, 504.

Metaxas, T.I., Koutlianos, N.A., Kouidi, E.J. and Deligiannis, A.P. (2005) Comparative study of field and laboratory tests for the evaluation of aerobic capacity in soccer players. *Journal of Strength and Conditioning Research* **19(1),** 79-84.

Mohr, M., Krustrup, P. and Bangsbo, J. (2003) Match performance of high-standard soccer players with special reference to development of fatigue. *Journal of Sports Sciences* **21(7)**, 519-528.

Mujika, I., S. Padilla, J. Ibañez, M. Izquierdo and E. Gorostiaga (2000) Creatine supplementation and sprint performance in soccer players. *Medicine and Science in Sport and Exercise* **32(2)**, 518 - 525.

Müller, E.S., Fleischamann, E., Coelho, C.W. and Poffo, H. (2006) Comparação do VO_{2MAX} e concentração de lactato sangüíneo em atletas de futsal e futebol profissional de Joinville. *XXIX Simpósio Internacional de Ciências do Esporte, Octubre 05-07, São Caetano, São Paulo-Brazil.* Book of Abstract. 313. In Portuguese.

Pavanelli, C., Chaves, R., Barros Neto, T., Barbosa, A. and Braga, C.A. (2004) Comparação do perfil da aptidão física de jogadores profissionais e juniores de futebol de acordo com a posição desempenhada. *XXVII Simpósio Internacional de Ciências do Esporte, Octubre 07-09, São Caetano, São Paulo-Brazil.* Book of Abstract. 304. In Portuguese.

Pereira, J.L., Walczak, M.E., Tonet, F., Mazzuco, M.A., Macuco, E.C., Siqueira, G.S., Sozzi, G., Kummer, L.F., Javoroski, T.M., Gibran, F.P. (2003) Diferenças no limiar anaeróbio indireto entre as diferentes posições de futebolistas juniores. *XXVI Simpósio Internacional de Ciências do Esporte, Octubre 23-25, São Caetano, São Paulo-Brazil.* Book of Abstract. 119. In Portuguese.

Petroni, R.G.G., Alves, T.B., Santana, H.A.P., Lana, R.P., Rodrigues, L.R., Arantes, L.M., Santos, T.P., DeAgostini, G.G. (2006) Há relação entre índice de fadiga e consumo indireto máximo de oxigênio em jogadores de futebol? *XXIX Simpósio Internacional de Ciências do Esporte, Octubre 05-07, São Caetano, São Paulo-Brazil.* Book of Abstract. 299. In Portuguese.

Pochmann, M.V. and Sacramento Neto, A.A. (2004) Resistência específica como base para a determinação de treino no futebol. *XXVII Simpósio Internacional de Ciências do Esporte, Octubre 07-09, São Caetano, São Paulo-Brazil.* Book of Abstract. 205. In Portuguese.

Raastad, T., Hostmark, A.T. and Stromme, S.B. (1997) Omega-3 fatty acid supplementation does not improve maximal aerobic power, anaerobic threshold and running performance in well-trained soccer players. *Scandinavian Journal of Medicine and Science in Sports* **7(1)**, 25-31.

Reilly, T. (1997) Energetics of high-intensity exercise (soccer) with particular reference to fatigue. *Journal of Sports Sciences* **15**, 257-263.

Reilly, T. (2005) An ergonomics model of the soccer training process. *Journal of Sports Sciences* **23(6)**, 561-572.

Reilly, T., Bangsbo, J. and Franks, A. (2000) Anthropometric and physiological predispositions for elite soccer. *Journal of Sports Sciences* **18(9)**, 669-683.

Rico-Sanz, J. (1998) Body composition and nutritional assessments in soccer. *International Journal of Sport Nutrition* **8(2)**, 113 - 123.

Rico-Sanz, J., M. Zehnder, R. Buchli, M. Dambach and U. Boutellier (1999) Muscle glycogen degradation during simulation of a fatiguing soccer match in elite soccer players examined noninvasively by 13C-MRS. *Medicine and Science in Sport and Exercise.* **31(11)**, 1587 - 1593.

Rienzi, E., Mazza, J.C., Carter, J.E.L. and Reilly, T. (1998) *Futbolista Sudamericano de Elite: Morphologia, Analysis del Juego y Performance*. Buenos Aires/Rosario, Biosystem Servicio Educativo. 64 - 88.

Rienzi, E., Drust, B., Reilly, T., Carter, J.E.L. and Martin, A. (2000) Investigation of anthropometric and work-rate profiles of elite South American international soccer players. *Journal of Sports Medicine and Physical Fitness* **40(2),**162-169.

Santos, D.A.S., Gomes, E.F. and Fernandes, M.L. (2005) Capacidade cardiorrespiratória de atletas de futebol do América/MG. *XXVIII Simpósio Internacional de Ciências do Esporte, Octubre 13-15, São Caetano, São Paulo-Brazil.* Book of Abstract. 249. In Portuguese.

Santos, P., Valente, A. and Soares, J. (2001) Aerobic capacity versus total distance covered during a game in elite soccer players. *Medicine and Science in Sport and Exercise* **33(5)**, S157.

Silva, J.G. and Minuzzi, L. (2006) Análise de VO_{2MAX} Em jogadores de futebol através de testes indiretos. *XXIX Simpósio Internacional de Ciências do Esporte, Octubre 05-07, São Caetano, São Paulo-Brazil.* Book of Abstract. 197. In Portuguese.

Silva, N.S. and Barros, S.A. (2000) Diferencial no VO_{2MAX} em jogadores profissionais de futebol de campo, salão e de praia. *XXIII Simpósio Internacional de Ciências do Esporte, Octubre 05-08, São Caetano, São Paulo-Brazil.* Book of Abstract. 77. In Portuguese.

Silva, O.F. and Soares, B. (2004) VO_{2MAX} de jogadores de futebol de campo: comparação entre posições. *XXVII Simpósio Internacional de Ciências do Esporte, Octubre 07-09, São Caetano, São Paulo-Brazil.* Book of Abstract. 201. In Portuguese.

Silva, P.R.S., Inarra, L.A., Vidal, J.R.R., Osberg, A.A.R.B., Fonseca Júnior, A., Roxo, C.D.M.N., Machado, G.S. and Teixeira, A.A.A. (2000) Níveis de lactato sanguíneo, em futebolistas profissionais, verificados após o primeiro e o segundo tempos em partidas de futebol. *Acta Fisiátrica* **7(2)**, 68-74. In Portuguese.

Silva, P.R.S., Romano, A., Yazbek Jr., P. and Basttitella, L.R. (1997a) Efeitos do treinamento físico específico nas respostas cardiorrespiratórias e metabólicas em repouso e no exercício máximo em jogadores de futebol profissional. *Acta Fisiátrica* **4(2)**, 59-64. In Portuguese.

Silva, P.R.S., Romano, A., Teixeira, A.A.A., Visconti, A.M., Roxo, C.D.M.N., Machado, G.S., Vidal, J.R.R. and Inarra, L.A. (1999) A importância do limiar anaeróbio e do consumo máximo de oxigênio em jogadores de futebol. *Revista Brasileira de Medicina do Esporte* **5(6)**, 225-232. In Portuguese.

Silva, S.G., Pereira, J.L., Kaiss, L., Kulaitis, A. and Silva, M. (1997b) Diferenças antropométricas e metabólicas entre jogadores de futebol das categorias profissional, junior e juvenil. *Revista Treinamento Desportivo* **2(3)**, 35-39. In Portuguese.

Silveira Jr., P.C.S., Monteiro, W.D., Soares, M.A.B., Amorim, P.R.S., Lira, V.A. and Silva, S.C. (1996) Variáveis fisiológicas e morfológicas de atletas brasileiros de alto nível. *XX Simpósio Internacional de Ciências do Esporte, Octubre 03-06, São Caetano, São Paulo-Brazil.* Book of Abstract. 55. In Portuguese.

Sözen, A. B., Akkaya, V., Demirel, S., Kudat, H., Tukek, T., Unal, M., Beyaz, M.M., Guven, O. and Korkut, F. (2000). Echocardiographic findings in professional league soccer players: effect of the position of the players on the echocardiographic parameters. *Journal of Sport Medicine and Physical Fitness* **40(2)**, 150 - 155.

Stølen, T., Chamari, K., Castagna, C. and Wisløff, U. (2005) Physiology of soccer: An update. *Sports Medicine* **35(6),** 501-536.

Strøyer, .J, Hansen, L. and Klausen, K. (2004) Physiological profile and activity pattern of young soccer players during match play. *Medicine and Science in Sport and Exercise* **36(1)**, 168-174.

Strudwick, A., T. Reilly and D. Doran (2002) Anthropometric and fitness profiles of elite players in two football codes. *Journal of Sports Medicine and Physical Fitness*. **42**, 239 - 242.

Teixeira, A.A.A., Silva, P.R.S., Inarra, L.A., Vidal, J.R.R., Lépera, C., Machado, G.S., Rebello, L.C.W., Prima, L.C., Zagallo, M.J.L. and Sousa, J.M. (1999) Estudo descritivo sobre a importância da avaliação funcional como procedimento prévio no controle fisiológico do treinamento físico de futebolistas realizado em pré-temporada. *Acta Fisiátrica* **6(2),** 70-77. In Portuguese.

Wilson, J. and P. G. O'Donoghue (2004) Physiological profiling of Northern Ireland amateur league soccer players. *Journal of Sports Sciences*. **23(2)**, 126.

Wisløff, U., Helgerud, J. and Hoff, J. (1998) Strength and endurance of elite soccer players. *Medicine and Science in Sport and Exercise* **30(3)**, 462-467.

Key points

- Physical and physiological differences exist between Brazilian soccer and European soccer.
- Players in Brazil appear to be shorter in stature, similar in body mass and have a lower overall aerobic capacity to their European equivalents
- In Brazil, there seems to be a physical development phase for players at U-20 level which prepares them for the demands at First Division level.

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