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Growth, maturity profile and peak vo2 of 11 year-old male soccer players

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GROWTH, MATURITY PROFILE AND PEAK VO₂ OF 11 YEAR-OLD MALE SOCCER PLAYERS

ABSTRACT

This study examined the relationship between body size, biological maturity, total amount of practice, and aerobic fitness of youth soccer players. The sample included 30 male soccer players aged 11 years old. Morphological variables (weight, height, sitting height and subcutaneous skinfolds), maturity (maturity offset, percentage of predicted mature height and skeletal maturity using the Fels method), quantity of annual practice and years of federate practice were considered. Assessment of aerobic power was obtained using a direct, maximal and progressive treadmill protocol. Data analysis considered general and comparative descriptive statistic. Pearson's correlation coefficient was calculated in order to consider the association between aerobic power outputs and morphology, maturity and sport participation parameters. **ANOVA** was used to compare variables by tactical playing position and among maturity status groups. Significance was maintained in 5%. The maturity status-associated analysis classifies more subjects on time (53%) followed by early mature (27%) and late mature (20%). Subjects classified as early matures showed higher average results for the morphological parameters (excluding sitting height/standing height ratio), amount of playing minutes and absolute aerobic power, while maturity delayed subjects showed higher relative aerobic power marks. Results illustrate defenders as taller, heavier, higher in adiposity, with superior amount of playing minutes and better in absolute aerobic power. We found strong correlations between absolute aerobic power and weight ($r=+0.90$, $p<0.01$), height ($r=+0.76$, $p<0.01$), maturity offset ($r=+0.80$, $p<0.01$) and percentage of predicted adult height ($r=+0.77$, $p<0.01$). Moderate correlation between absolute aerobic power and amount of playing minutes ($r=+0.34$, $p<0.05$) was also found. Aerobic power seems to be associated with body size and maturity status. It seems that the process of sportive selection favours body size and maturity advanced athletes. Nevertheless, it seems that youth soccer coaches tend to select those players to defensive playing positions.

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KEYWORDS: Youth Soccer. Biological maturity. Aerobic power.

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INTRODUCTION

Soccer is unarguably the most popular sport in the world (Reilly, Bangsbo & Franks, 2000). In the particular case of Portugal, soccer occupies a social position of great prominence (Ramos, 2002). On the other hand, as stated by Morris (2000), early identification of future elite athletes will offer greater competitive potential to the sport organizations with that kind of capability. Paradoxically, the sports models used by most of professional clubs still seem to use too much support from empirical knowledge (Vaeyens et al., 2006).

Studies related to multidimensional research on youth soccer players (Malina et al., 2000; Seabra, Maia & Garganta, 2001; Fragoso et al., 2004; Malina et al., 2005; Philippaerts et al., 2006; Vaeyens et al., 2006; Malina, Ribeiro, Aroso & Cumming, 2007; Figueiredo, Gonçalves, Coelho e Silva & Malina, 2009) have been increasing in the last decade, but still left open more discriminating analysis considering factors of metabolic response through the use of laboratory tests.

Due to the length of the game, aerobic metabolism is the main source in soccer (Bangsbo, 1994; Impellizzeri, Moggi, Sassi & Rampinini, 2005; Stølen, Chamari, Castagna & Wisløff, 2005; Svensson & Drust, 2006). According to Reilly, Bangsbo & Franks (2000), the energy expenditure associated with match play revolves around 5700 kJ for a male soccer player with total body mass of about 75 kg. Maximal oxygen uptake has been studied in several studies with elite adult soccer players. Considering mean values, these are located between 56 and 69 ml.kg⁻¹.min⁻¹ (Reilly, Bangsbo & Franks, 2000). Although Wisløff, Helgerud & Hoff (1998) point out that the average values for elite player can be greater than 65 ml.kg⁻¹.min⁻¹ (considering variability associated with tactical playing position), Reilly (2004) suggests that there is a threshold value of about 60 ml.kg⁻¹.min⁻¹, which represents the minimum for a soccer player to succeed in a contemporary elite team. Although players of different tactical playing positions have a different workload during a game, which demonstrates that some of the training sessions should be dedicated to training specific to each position, few studies of young soccer players are available to date (Gil et al., 2007).

VO₂max develops just like other process related to growth and maturation during childhood and adolescence (Helmantel, Elferink-Gemser & Visscher, 2009), appearing to occur a stabilization of values expressed per unit body mass as a result of aging (Malina, Bouchard & Bar-Or, 2004b). Furthermore, Beunen et al. (2002) found that although VO₂max is largely explained by body mass, factors such as regular physical activity and his interaction with maturity status contribute independently to the VO₂max. Maturity advanced boys attain higher absolute (L.min⁻¹) VO₂max compared with delayed maturity subjects. When regarding to relative results (ml.kg⁻¹.min⁻¹), late maturity boys achieve higher rate of oxygen absorption per unit body mass, except in early adolescence.

Boys, as they enter puberty, experience a significant increase of VO₂max that reaches maximum gains during peak height velocity (PHV), continuing to increase up to 16 years of age despite the decline in growth rate, suggesting that puberty influences improvement

in aerobic fitness by increasing body size, particularly of cardiac dimensions, lungs, muscles and circulatory system (Geithner et al., 2004; Malina, Bouchard & Bar-Or, 2004b; Armstrong & Welsman, 2005; Rowland, 2004).

Although VO₂max is the most commonly used term for maximal achieved oxygen uptake, the term more appropriated and suitable for children and youth is peak oxygen uptake (Armstrong, 2006; Mamen, Resaland, Mo & Anderson, 2009), which is a stout variable that is positively associated with the determination of VO₂max in adults (Welsman, Bywater, Farr, Welford & Armstrong, 2005). The purpose of this study is to examine the association between morphology, maturity assessed using more than a single methodology, amount of annual practice, and aerobic fitness of youth soccer players, considering as well tactical playing position and maturity associated patterns.

METHODS

The sample included 30 male soccer players aged 11.3 –12.3 years (11.9 ± 0.3) from three clubs in the midlands of Portugal. The athletes were grouped in four playing position categories: Goalkeepers ($n = 2$), Defenders ($n=9$), Midfielders ($n=11$) and Forwards ($n=8$). All subjects were informed of the procedures involving data recording, giving authorization for data recording and divulgation, but not personal information.

Weight, height and sitting height were taken. The triceps, biceps, subscapular, suprailiac and medial calf skinfolds (Carter and Heat, 1990) were measured. The body mass index (BMI, kg/m²) and sitting height/standing height ratio (%) were also calculated.

Maturation was assessed through somatic indicators such as *maturity offset* (Mirwald, Baxter-Jones, Bailey, & Beunen, 2002) and *percentage of predicted adult height* (%PAH) (Khamis & Roche, 1994 and 1995). Hand-wrist radiographs were also taken in order to provide an estimate of skeletal maturity. The Fels method was used to estimate a skeletal age for each child (Roche, Chumlea & Thissen, 1988). A single experienced individual assessed all the radiographs.

Chronological age (CA) was subtracted from skeletal age (SA) for each child to provide an estimate of the skeletal maturity status (Peña Reyes, Cardenas-Barahona & Malina, 1994; Malina et al., 2000; Peña Reyes & Malina, 2004) for each subject as follows:

- *Late* (delayed) = SA behind CA by more than one year;
- *Average* (on time) = SA within plus or minus one year of CA;
- *Early* (advanced) = SA ahead of CA by more than one year.

Assessment of aerobic power (peak VO₂) was obtained using a direct, maximal and progressive treadmill protocol. Initially the children were habituated to both the general

environment and the specific experimental procedures and then they warmed up by running on the treadmill at a speed of 5 km/h for 3 minutes, ending at the initial speed of the protocol, 8 km/h. The test had its beginning at a speed of 8 km/h with an increment of 1 km/h for every stage of 3 minutes. After setting the speed of 12 km/h on the fifth stage the load increments were promoted through slope, where in each stage increased 2.5%.

The test was performed until voluntary exhaustion of the subject. After finishing the test, every subject performed an active recovery (5 minutes) on a bicycle ergometer Monarc 824E, without charge, at a constant speed of 60 rpm. If the child showed signs of intense effort (hyperpnea, facial flushing, unsteady gait, sweating), supported by a heart rate leveled about 220 bpm⁻¹ minus age in years (range $\pm 5\%$) and a respiratory exchange ratio at least 1.0, peak VO₂ was accepted as a maximal index. Also, when an increase not exceeding 2 ml.kg⁻¹.min⁻¹ despite an increase in load was verified, the attainment of VO₂max was accepted as well (Armstrong, Welsman & Winsley, 1996; Armstrong, Welsman & Kirby, 1998; Armstrong & Welsman, 2001; Geithner et al., 2004; Malina, Bouchard & Bar-Or, 2004b).

Throughout the tests, inspired and expired gases were monitored continuously using an analysis system (*Metamax Ergospirometry System; Cortex Biophysite GmbH 1991-1998*) that was recalibrated prior to each test. Heart rate was monitored using a cardiofrequencimeter Polar S – 810.

The authors individually registered the number of training sessions, games and respective minutes over one season (2009 – 2010) on a weekly basis. Information about the number of seasons in federate sport was also gathered for each subject.

A sample of 10 players was measured on a second occasion within one week. Intra-observer technical errors of measurement and coefficients of reliability for anthropometric dimensions were calculated. The technical error of measurement is the square root of the squared differences of replicates divided by twice the number of pairs:

$$\sigma_e = \sqrt{\sum d^2 / 2N} \text{ (Malina, Hamill and Lemeshow, 1973).}$$

It is also known as the measurement error standard deviation. The coefficient of reliability is based on the ratio of within-subject (r) and inter-subject (s) variances:

$$R = 1 - (r^2/s^2) \text{ (Mueller and Martorell, 1988).}$$

Higher values indicate greater reliability. Technical errors and reliability coefficients for the present study are summarized in Table 1. Technical errors for anthropometric dimensions compare favorably with corresponding intra-observer errors in several health surveys in the United States and a variety of field surveys (Malina, 1995), while reliability coefficients indicate high reliabilities.

Table 1. Intra-observer technical errors of measurement (σ_e) and reliability coefficients (R) for anthropometric dimensions (n=10).

	σ_e	R
Weight, kg	0.25	1.00
Height, cm	0.75	0.99
Sitting height, cm	0.72	0.97
Skinfolds, mm		
Triceps	0.50	0.98
Biceps	0.47	0.97
Subscapular	0.32	0.98
Suprailiac	0.52	0.97
Medial calf	0.42	0.99

Data analysis considered general and comparative (maturity status and playing position) descriptive statistic. Pearson's correlation coefficient was calculated in order to analyse the association between aerobic power outputs and morphology, maturity and sport participation parameters. One-way analysis of variance (ANOVA) was used to compare CA, maturity variables, body size and proportions, annual amount of practice and aerobic power by tactical playing position and among late, average (on time) and early maturing players within competitive age group. Significance was maintained in 5%.

RESULTS

Descriptive statistics for variables of biological maturity and years of federate practice are summarized in table 2. There is a greater range of variance of skeletal age (5.9 years) compared to chronological age (1.0 years), within this age group of soccer players. It was estimated that, on average, peak height velocity (PHV) will occur at about 13.8 years of age and also, moreover, the subjects of our sample are currently approximately 2.2 years from achieving this biological event.

Table 2.Descriptive statistics (mean ± sd) and range values (maximum – minimum) for biological maturity and years of federate practice (n=30).

	Minimum	Maximum	Range	Mean ± SD
Chronological Age, yrs	11.3	12.3	1.0	11.9 ± 0.3
Skeletal Age, yrs	8.7	14.6	5.9	12.0 ± 1.5
Maturity Offset, yrs	-3.10	-0.60	2.5	-2.20 ± 0.60
Age PHV, yrs	12.7	14.6	1.9	13.8 ± 0.4
PAH, %	78.8	90.7	11.9	83.6 ± 2.6
FederatePractice, yrs	1	6	5	3.8 ± 1.5

Table 3 summarizes descriptive statistics for morphology, total amount of annual practice and aerobic power. The absolute and relative mean values for peak VO₂ were estimated in 2.33 L.min⁻¹ and 60.9 ml.kg⁻¹.min⁻¹ respectively. There is a significant range of variation within this age group of soccer players for body mass and height, 53.7 kg and 35.0 cm respectively. The average annual volume for each player, concerning sport participation, (training sessions and games) was estimated in 7179.4 minutes.

Table 3.Descriptive statistics (mean ± sd) and range values (maximum – minimum) for morphology variables, amount of annual practice and aerobic power (n=30).

	Minimum	Maximum	Range	Mean ± SD
Weight, kg	29.4	83.1	53.7	38.8 ± 10.0
Height, cm	132.5	167.5	35.0	146.0 ± 8.1
BMI, kg/m ²	15.3	33.4	18.1	18.1 ± 3.2
SitHt/Ht Ratio, %	48.7	54.2	5.5	51.7 ± 1.3
Sum of skinfolds, mm	19	78	59	32.0 ± 12.3
Training sessions, #	47	102	55	81.4 ± 16.1
Game sessions, #	4	24	20	15.5 ± 5.2
Annual sessions, #	54	126	72	96.9 ± 20.1
Training minutes, min	2820	9060	6240	6596.0 ± 2044.0
Game minutes, min	113	1350	1237	583.4 ± 239.6
Annual minutes, min	3210	10410	7200	7179.4 ± 2146.1
Treadmill – stage	3	8	5	5.8 ± 1.1
Treadmill – final HR, bpm	179	212	33	197.2 ± 8.8
Treadmill – RER	0.90	1.02	0.12	0.96 ± 0.03
Peak VO ₂ , L.min ⁻¹	1.66	3.88	2.22	2.33 ± 0.43
Peak VO ₂ , ml.kg ⁻¹ .min ⁻¹	46.7	70.1	23.4	60.9 ± 5.9

The average values and standard deviations for biological maturation and years of federate practice, grouping the subjects according to their tactical playing position, are considered in table 4. Defenders showed higher mean results for skeletal age and percentage of predicted adult height (%PAH), as well as they are significantly older (CA) and have more years in the competitive formal process ($F=4.74$, $p<0.01$). Data further demonstrates that defenders are, significantly, closer to peak height velocity (PHV) and therefore they are expected to reach that point at earlier ages, comparing to the remaining groups.

Table 4 Descriptive statistics (mean $\pm$ sd) and results of ANOVAs for biological maturity and years of federate practice, considering tactical playing position (n=28).

Variable	Tactical Playing Position			F	p
	Defenders (n=9)	Midfielders (n=11)	Forwards (n=8)		
	Mean $\pm$ SD	Mean $\pm$ SD	Mean $\pm$ SD		
Chronological Age, yrs	12.1 $\pm$ 0.2	11.7 $\pm$ 0.2	11.9 $\pm$ 0.3	6.19	<0.01
Skeletal Age, yrs	12.8 $\pm$ 1.8	12.1 $\pm$ 1.0	11.6 $\pm$ 1.2	2.80	-
Maturity Offset, yrs	-1.73 $\pm$ 0.72	-2.38 $\pm$ 0.45	-2.39 $\pm$ 0.44	3.22	<0.05
Age PHV, yrs	13.6 $\pm$ 0.6	13.8 $\pm$ 0.3	14.1 $\pm$ 0.3	1.75	-
PAH, %	85.0 $\pm$ 3.7	83.0 $\pm$ 1.8	83.1 $\pm$ 1.9	1.43	-
Federate Practice, yrs	4.8 $\pm$ 1.0	3.9 $\pm$ 1.6	2.5 $\pm$ 0.9	4.74	<0.01

* Goalkeepers (n=2) were not considered

Table 5 considers descriptive statistics for morphology, total amount of annual practice and aerobic power, according to maturity status groups - given by the difference between skeletal and chronological age. When regarding to the indicators of external morphology, we verified a growing trend for weight and height considering delayed, average and early mature groups. This trend was also established for peak $VO_2(L.min^{-1})$. On the other hand, when peak VO_2 was considered in relation to body mass ($ml.kg^{-1}.min^{-1}$) the results were significantly ($F=4.42$, $p<0.05$) higher in the late maturity group. It is also observable that the advanced maturity soccer players attained higher mean results for game sessions (16.8 annual game sessions) and game minutes (622.1 annual game minutes).

Table 5 Descriptive statistics (mean $\pm$ sd) and results of ANOVAs for morphology variables, amount of annual practice and aerobic power, considering maturity status (n=30).

Variable	Maturity Status			F	p
	Late (n=6)	Average (n=16)	Early (n=8)		
	Mean $\pm$ SD	Mean $\pm$ SD	Mean $\pm$ SD		
Weight, kg	33.1 $\pm$ 3.3	39.8 $\pm$ 12.3	41.3 $\pm$ 6.9	1.34	-
Height, cm	140.7 $\pm$ 5.4	145.6 $\pm$ 6.8	150.9 $\pm$ 10.1	3.17	-
BMI, kg/m ²	16.7 $\pm$ 0.7	18.6 $\pm$ 4.2	18.0 $\pm$ 1.4	0.75	-
SitHt/Ht Ratio, %	51.5 $\pm$ 1.0	52.2 $\pm$ 1.0	50.9 $\pm$ 1.6	2.99	-
Sum of skinfolds, mm	23.2 $\pm$ 3.4	35.5 $\pm$ 15.3	31.6 $\pm$ 4.7	2.41	-
Training sessions, #	87.0 $\pm$ 19.7	79.1 $\pm$ 15.5	81.8 $\pm$ 15.8	0.51	-
Game sessions, #	15.2 $\pm$ 8.9	15.0 $\pm$ 4.3	16.8 $\pm$ 3.4	0.31	-
Annual sessions, #	102.2 $\pm$ 27.5	94.1 $\pm$ 18.6	98.5 $\pm$ 18.7	0.37	-
Training minutes, min	7495.0 $\pm$ 2305.3	6135.0 $\pm$ 1910.4	6843.8 $\pm$ 2107.9	1.05	-
Game minutes, min	585.2 $\pm$ 441.0	563.3 $\pm$ 197.5	622.1 $\pm$ 112.8	0.15	-
Annual minutes, min	8080.2 $\pm$ 2590.8	6698.3 $\pm$ 1962.4	7465.9 $\pm$ 2171.8	1.00	-
Treadmill – stage	6.3 $\pm$ 1.0	5.7 $\pm$ 1.3	5.6 $\pm$ 0.9	0.84	-
Treadmill – HR, bpm	201.7 $\pm$ 7.6	194.8 $\pm$ 9.1	198.8 $\pm$ 8.4	1.53	-
Treadmill – RER	0.97 $\pm$ 0.04	0.96 $\pm$ 0.04	0.97 $\pm$ 0.03	0.46	-
Peak VO ₂ , L.min ⁻¹	2.18 $\pm$ 0.22	2.29 $\pm$ 0.49	2.55 $\pm$ 0.38	1.55	-
Peak VO ₂ , ml.kg ⁻¹ .min ⁻¹	65.9 $\pm$ 2.4	58.5 $\pm$ 6.4	62.1 $\pm$ 4.2	4.42	<0.05

Descriptive statistics for morphology, total amount of annual practice and aerobic power, considering tactical playing position groups are summarized in table 6. Defenders are significantly heavier ($F=2.87$, $p<0.05$) and showed higher mean results for height, as well as for sum of skinfolds and body mass index. In addition to body size, defenders also attained significantly better results for absolute peak VO₂ ($F=3.01$, $p<0.05$). In the meantime, when the variable is considered in relation to body mass, the mean results are higher in forwards (62.2 ml.kg⁻¹.min⁻¹) followed by midfielders (62.0 ml.kg⁻¹.min⁻¹) and defenders (59.1 ml.kg⁻¹.min⁻¹). Further more, defenders have accumulated significantly more game minutes during the previous season ($F=3.84$, $p<0.05$).

Table 6 Descriptive statistics (mean $\pm$ sd) and results of ANOVAs for morphology variables, amount of annual practice and aerobic power, considering tactical playing position (n=28).

Variable	Tactical Playing Position			F	p
	Defenders (n=9)	Midfielders (n=11)	Forwards (n=8)		
	Mean $\pm$ SD	Mean $\pm$ SD	Mean $\pm$ SD		
Weight, kg	46.3 $\pm$ 15.6	35.7 $\pm$ 4.2	35.1 $\pm$ 2.9	2.87	<0.05
Height, cm	151.5 $\pm$ 10.4	144.2 $\pm$ 6.1	142.6 $\pm$ 6.2	2.33	-
BMI, kg/m ²	19.9 $\pm$ 5.1	17.2 $\pm$ 1.8	17.3 $\pm$ 1.4	1.44	-
SitHt/Ht Ratio, %	51.4 $\pm$ 1.3	52.1 $\pm$ 1.6	51.8 $\pm$ 0.8	0.64	-
Sum of skinfolds, mm	37.2 $\pm$ 16.0	29.9 $\pm$ 11.3	28.1 $\pm$ 7.2	0.96	-
Training sessions, #	87.9 $\pm$ 10.2	75.6 $\pm$ 16.4	77.8 $\pm$ 19.2	1.97	-
Game sessions, #	17.8 $\pm$ 3.1	15.4 $\pm$ 3.7	12.9 $\pm$ 7.0	1.34	-
Annual sessions, #	105.7 $\pm$ 12.9	91.0 $\pm$ 19.7	90.6 $\pm$ 24.6	1.79	-
Training minutes, min	7053.3 $\pm$ 1772.5	6283.6 $\pm$ 2047.2	6322.5 $\pm$ 2495.0	0.35	-
Game minutes, min	712.8 $\pm$ 158.5	535.9 $\pm$ 140.3	433.4 $\pm$ 200.1	3.84	<0.05
Annual minutes, min	7766.1 $\pm$ 1768.2	6819.6 $\pm$ 2100.7	6755.9 $\pm$ 2582.2	0.56	-
Treadmill – stage	5.2 $\pm$ 1.2	6.2 $\pm$ 1.1	6.0 $\pm$ 1.1	1.40	-
Treadmill – HR, bpm	195.6 $\pm$ 6.2	198.7 $\pm$ 9.9	198.9 $\pm$ 9.0	0.73	-
Treadmill – RER	0.96 $\pm$ 0.04	0.98 $\pm$ 0.04	0.95 $\pm$ 0.02	1.16	-
Peak VO ₂ , L.min ⁻¹	2.66 $\pm$ 0.60	2.21 $\pm$ 0.28	2.18 $\pm$ 0.19	3.01	<0.05
Peak VO ₂ , ml.kg ⁻¹ .min ⁻¹	59.1 $\pm$ 7.5	62.0 $\pm$ 5.4	62.2 $\pm$ 3.9	0.66	-

* Goalkeepers (n=2) were not considered

Correlations between peak VO₂ and morphology, biological maturity, and sport participation parameters are summarized in table 7. Results suggests, for absolute peak VO₂, strong correlations with weight, height, body mass index, maturity offset, age at peak height velocity and percentage of predicted adult height. Moderate correlations were also found for sum of skinfolds, chronological age, skeletal age and annual game minutes. Regarding to relative peak VO₂, we found a strong, negative correlation with sum of skinfolds and also negative, moderate correlations with weight and body mass index. A positive, moderate correlation with age in peak height velocity was found as well. The results suggest that maturity advanced soccer players, with larger body size, achieved better absolute peak VO₂ results and, furthermore, youth soccer players with higher absolute peak VO₂ were more often selected by coaches during the previous season.

Table 7 - Correlations between peak VO2 outputs and morphology, biological maturity, years of federate practice and amount of annual practice (n=30).

	Peak VO2, L.min ⁻¹	Peak VO2, ml.kg ⁻¹ .min ⁻¹
Weight, kg	+0.90**	-0.56**
Height, cm	+0.76**	-0.20
BMI, kg/m ²	+0.72**	-0.63**
SitHt/Ht Ratio, %	-0.18	-0.05
Sum of skinfolds, mm	+0.51**	-0.77**
Chronological Age, yrs	+0.46*	+0.09
Skeletal Age, yrs	+0.42*	-0.19
Maturity Offset, yrs	+0.80**	-0.32
Age PHV, yrs	-0.71**	+0.39*
PAH, %	+0.77**	-0.24
Federate Practice, yrs	+0.21	+0.09
Training sessions, #	+0.13	-0.05
Game sessions, #	+0.23	+0.11
Annual sessions, #	+0.16	-0.02
Training minutes, min	+0.04	+0.09
Game minutes, min	+0.34*	+0.03
Annual minutes, min	+0.08	+0.09

n.s. (not-significant). * (p<.05). ** (p<.01).

DISCUSSION

Assuming data from the *Centers for Disease Control and Prevention* – United States of America (2001) as a reference, mean heights from our sample are between the 25th and 50th percentiles. If we split the sample into tactical playing position groups, this same trend is only observed for midfielders, while forwards are located close to the 25th percentile. Defenders, on the other hand, are between the 50th and 70th percentiles. Considering mean weights, similar trends were found. However, results approximate the 75th percentile in the defenders group, taking into account tactical playing position. Physical contact, concerning soccer, is crucial in areas closer to the goals. Thus, youth soccer coaches seem to select heavier and taller players to those field areas – defenders and forwards (Figueiredo, 2007). The results from our investigation seem to fit into this conjecture, but only when regarding to defenders.

Age at peak height velocity was estimated using the maturity offset (Mirwald, Baxter-Jones, Bailey, & Beunen, 2002). Malina et al. (2006) described this method as noninvasive and efficient, whilst acknowledging some reservations to its applications. According to Mirwald, Baxter-Jones, Bailey, & Beunen (2002) the age of occurrence of this biological event can be determined in 95% of cases, with an accuracy of 1.0 years. Thus, it seems that this methodology enables to gather the subjects, with some certainty, in equivalent maturity groups (Figueiredo, 2007).

Apart from the conceptual sphere of scientific research, we believe that the ability to fit young soccer players in the growth curve rate can be quite useful as we can place the period in which the subject is growing faster, consequently more vulnerable to inadequate training plans or, therefore, more in need of a specific, individualized, training intervention. Our results suggest that peak height velocity will occur, on average, at 13.8 years of age. Similar results were already found for European population (Malina, Bouchard & Bar-Or, 2004b) and for youth soccer players (Philippaerts et al., 2006).

The distribution of soccer players in the categories resulting from the discrepancy between skeletal age and chronological age evidence that the group classified as average or “on time” has a higher presence (53.3%), followed by early matures (26.7%) and late matures (20.0%). These results are in line with the evidence reported by Malina (2004a), in which young athletes (boys) tend, with some exceptions, to be “on time” or early matures. In the meantime, Le Gall, Carling & Reilly (2007) found, with a considerably larger sample of soccer players (n=233) but with an older age group (Under 14), a substantial lower percentage of late matures. This evidence seems to meet the trends reported by Malina et al. (2000), Peña Reyes & Malina (2004) and Figueiredo, Gonçalves, Coelho e Silva & Malina (2009), regarding that with sport experience and aging maturity advanced athletes seem to appear more frequently within their respective specific sports. We have, however, to establish a limitation when approaching to Le Gall, Carling & Reilly (*op cit.*) study, since the skeletal age method used (Greulich-Pyle) was different from the one we used in the present study (Fels).

Young athletes tend to have higher levels of aerobic power per unit body mass than the general population children and youth non-athletes (Malina, Bouchard & Bar-Or, 2004). This trend finds echo in previous researches (Eisenman, Pivarnik & Malina, 2001; Chamari et al., 2004; Montfort-Steiger, Williams & Armstrong, 2005; Metaxas, Koutlianos, Kouidi & Deliggianis, 2005; Castagna, Impellizzeri, Rampinini, D’Ottavio & Manzi, 2008). Our results strengthen the framework of evidence and show youth soccer players as athletes who demonstrate values of relative peak VO₂ similar to those found for their peers from other sports. Yet, it must be considered that among the referenced studies only the investigation of Eisenman, Pivarnik & Malina (*op cit.*) corresponds to the age group of our sample. The other sample sets are between 15.7 and 18.1 years of age. In the meantime, and considering only age groups similar to our sample of soccer players, our results were higher than those found in groups of healthy children reported in the studies of Armstrong, Kirby & McManus (1995), Rowland, Goff, Martel & Ferrone (2000), Vinet et al. (2003) and Gursel, Sonel, Gok & Yalçin

(2004). This trend is also verifiable if the results are compared with healthy trained children (Nourry et al., 2004). When the values are considered in absolute terms, the evidence remains, considering all the studies already referenced.

Our study does not fit the perspective characterized by Stølen, Chamari, Castagna & Wisløff (2005), which stated that youth soccer players tend to show lower values of relative VO_2max ($<60 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$) compared to adult athletes. However, there is still a gap to be filled when it comes to analyzing studies with young soccer players in pubescent ages.

There is a strong association between maximum oxygen consumption and body size (Malina, Bouchard & Bar-Or, 2004b). The same authors reported that there appeared to be a stabilization of the values expressed per unit body mass, as a result of aging, suggesting a proportional increase between the maximum oxygen consumption and body size. These evidences seem to be observable in our study, as it is clear a very high degree of association between absolute aerobic power and body mass. We found, as well, high correlations with height and body mass index. When the values of aerobic power are considered in relation to body mass, the most obvious sign is that all associations are to be inversely proportional and of lesser magnitude of correlation, except the sum of skinfolds, which still presents a strong, negative correlation.

Our study seems to point towards that young soccer players who are advanced in maturity, achieve better results in the test of aerobic power. However, when peak VO_2 considers body mass, late mature athletes seem to get better results. These findings are in line with Malina & Bouchard (1991) and Armstrong & Welsman (2001). This trend is further strengthened by the values of aerobic power in young soccer players according to maturity status given by the discrepancy between skeletal age and chronological age. In the present investigation the highest values of absolute aerobic power were estimated for the advanced maturity status group. On the other hand, when the figures take into account the body weight, it appears that is the group of delayed maturity status that presents the higher results.

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The present investigation seem to confirm the trends that, on the one hand, improvements in aerobic fitness are associated with maturation and increased body size (Armstrong & Welsman, 2005; Geithner et al., 2004; Malina, Bouchard & Bar-Or, 2004b) and, secondly, young athletes who are maturity advanced are privileged in relation to their peers “on time” and delayed (Peña Reyes & Malina, 2004; Figueiredo, Gonçalves, Coelho e Silva & Malina, 2009).

The sample from the present investigation corresponds to the same specific age group (11-year-olds), which restraint in the comprehension and inference about the sport training process. Upcoming studies should extend the sample and the number of subjects for each tactical playing position, as well as to monitor the data quality control for skeletal age and aerobic power variables. Since the interpretation of aerobic power in young people is confounded by the need of suitably partition out body size variation, the use of scaling techniques is needed.

CONCLUSIONS

Our study supports the reported evidences which state that aerobic power increase in direct proportion to body mass. It is also supported that maturity advanced boys attain higher absolute peak $\text{VO}_2(\text{L} \cdot \text{min}^{-1})$ but, on the other hand, maturity delayed boys reach higher peak VO_2 results per unit body mass ($\text{ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$). Regarding to tactical playing position, the defenders from our sample showed higher results for morphology, biological maturation and absolute peak VO_2 . They also attained higher values concerning to annual average game minutes. In other words, they were chose more often by coaches in their respective competitive process.

The evidence from our study seems to point that coaches tend to select young maturity advanced athletes to areas of the field nearest to the goal posts (where physical contact seems to be crucial). It seems to subsist, moreover, a hypothetical exacerbated concern about the defensive process, since the young players classified as forwards, besides less selected by coaches compared to defenders and midfielders, were also smaller, thinner and delayed in the maturity process.

Each tactical playing position seems to be related to a different functional and morphological profile that may, however, be related to the sport selection process, when using the maturity status of the young soccer player as the main criterion. Furthermore, youth soccer coaches must be aware that, besides playing position patterns and even in the same particular age group, there are significant differences regarding to morphology and aerobic fitness of youth soccer players in the same age group, so the training process itself must be carefully defined and adapted. Subsequently, more studies are needed.

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