

Original article (short paper)

Morphological and maturational predictors of technical performance in young soccer players

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Abstract—The purpose of the present study is to describe the association between chronological age, morphology, biological maturation and sport experience in relation to technical performance in young Brazilian soccer players. Technical, maturation and anthropometric variables were assessed in 119 soccer players, 74 and 45 in the under-15 and under-17 categories, respectively. Data were analyzed using a multiple linear regression model. Adiposity was negatively associated with technical performance regardless the age-category. Weight was negatively associated with technical performance in under-15 and positively with the under-17 category, respectively. In under-17 biological maturation was negatively related to the dribbling test and positively associated with the ball control test. Years of experience proved to be positively associated with technique taught to soccer player in the under-17 category. The explained variance was different between categories. The technical performance of Brazilian soccer players aged 14-to-17 seems to be related to biological maturation, adiposity, weight and years of experience.

Keywords: Technical skills, biological maturation, soccer

Resumo—“Preditores morfológicos de maturação e de desempenho técnico em jovens jogadores de futebol.” O objetivo deste trabalho é o de descrever a associação entre idade cronológica, morfologia, maturação biológica e anos de experiência esportiva no desempenho técnico de jovens futebolistas brasileiros. Variáveis antropométricas, relacionadas com a maturação biológica e técnicas foram avaliadas em 119 futebolistas das categorias sub-15 ($n=74$) e sub-17 ($n=45$). Para análise dos dados utilizou-se a estatística descritiva e a regressão linear múltipla. A adiposidade mostrou-se negativamente associada ao desempenho técnico. O peso corporal atuou negativamente nos sub-15 e positivamente nos sub-17. Nos sub-17 a maturação biológica mostrou-se negativamente relacionada com o teste condução de bola e positivamente ao teste de controle de bola; anos de experiência mostrou-se associada positivamente na técnica no sub-17. A variância explicada foi diferente entre as categorias. O desempenho técnico de jovens futebolistas brasileiros com idades entre os 14 e 17 anos parece estar relacionado com a maturação biológica, adiposidade subcutânea, peso corporal e anos de experiência.

Palavras-chave: Habilidades técnicas, maturação biológica, futebol

Resumen—“Predictores morfológicos de maduración y rendimiento técnico en jóvenes jugadores de fútbol.” El objetivo del estudio es describir la asociación entre edad cronológica, morfología, maduración biológica y la experiencia deportiva en el rendimiento técnico de los jóvenes futbolistas brasileños. Variables antropométricas, maduración biológica y técnicas fueron evaluadas en 119 jugadores. Para el análisis de los datos se utilizó estadística descriptiva y regresión lineal múltiple. Adiposidad corporal se asoció negativamente con el rendimiento técnico. Peso corporal actuó negativamente en la sub-15 y positivamente en la sub-17. En sub-17 la maduración biológica se relacionó negativamente con la prueba de conducción de la pelota y positivamente con el control; Años de experiencia se asoció positivamente con la técnica en la sub-17. La varianza explicada fue diferente entre las categorías. Maduración biológica, adiposidad, peso corporal y años de experiencia son capaces de explicar el rendimiento técnico de los jóvenes futbolistas brasileños.

Palabras clave: Habilidades técnicas, maduración biológica, fútbol

Introduction

Soccer performance is the result of an interaction among tactical, technical, functional and psychosocial factors (Williams, & Reilly, 2000). Understanding and explaining the variability of these factors and their relationship with soccer performance in different age categories has been an important challenge for researchers and coaches involved in the process of identifying, selecting, and developing young soccer players (Vaeyens *et al.*, 2006). A number of studies have investigated biological maturation and its relationship with technical performance in young soccer players (Figueiredo, Gonçalves, Silva, & Malina, 2009a; Gil, Ruiz, Irazusta, Gil, & Irazusta, 2007; Malina *et al.*, 2000; Vaeyens *et al.*, 2006). The biological maturation does not appear to explain the generality of the differences that are observed in the performance of young soccer players. Several authors have shown that some adolescents classified as late matured often exhibit a similar (or higher) technical performance than their maturely advanced peers, suggesting that other factors have the potential to influence their performance (Meylan, Cronin, Oliver, & Hughes, 2010). For that reason, it is relevant to develop studies designed to identify the relative contribution of different morphological and maturational indicators in technical performance among different age categories, as this may facilitate the identification, selection, and development of soccer talents (Vaeyens *et al.*, 2006).

The available literature has demonstrated that morphological, biological maturation and training process indicators have different effects on technical performance (Figueiredo *et al.*, 2011; Malina, Eisenmann, Cumming, Ribeiro, & Aroso, 2005; Rebelo *et al.*, 2013). Figueiredo *et al.* (2011) have analyzed Portuguese youth soccer players with ages between 11-12 and 13-14 years and identified that the chronological age and adiposity are the main explanatory variables of technical skills in 11-12-year-old players, whilst for those aged 13-14 years such variables were chronological age and sports experience. Malina *et al.* (2005) have observed that sexual maturation, years of practice and height explain 14% of technical performance of Portuguese soccer players in the under-15 category.

Considering that the technical skills are a central factor in the performance of young soccer players (Malina *et al.*, 2005), it is perceived that studies aiming to explain technical performance related to morphological, biological maturation and training process indicators in young soccer players are relatively scarce. In addition, the literature is also related to the geographical region where the studies were conducted. Namely, there are virtually no studies seeking to understand and explain the technical performance of young Brazilian soccer players in the more competitive age groups. Moreover, the studies previously referred (Figueiredo *et al.*, 2011; Malina *et al.*, 2005) focused on age groups in the beginning of specialization, while literature considering the later stages of youth soccer training programs is scarce. Since competition level increase in the final stage of specialization, maturational factor is expected to explain variations in the overall performance that includes the technical capacities. Considering these particular oversights of the current literature, the main purpose of this study was to examine the association

between morphological (stature, body mass, and subcutaneous adiposity), biological maturation (sexual and skeletal maturation), and training process (years of soccer experience) indicators and technical performance in young Brazilian soccer players in the under-15 and under-17 age categories.

Methods

Participants

The sample was composed by 119 male Brazilian soccer players: 74 and 45 in the under-15 and under-17 categories respectively, who belonged to 5 soccer teams in the State of Minas Gerais, and played in competitions organized by the Soccer League of the city of Juiz de Fora and by the Soccer Federation of Minas Gerais. The study was approved by the Research Ethics Committee of the Federal University of Juiz de Fora (# 009/11). The players and their guardians signed the informed consent form to participate in this study.

Morphological characteristics

The somatic indicators assessed included stature, body weight, and skinfolds (triceps, subscapular, suprailiac, and calf) following the standardizations suggested by Lohman, Roche, and Martorell (1988). These variables were measured by the same observer.

Skeletal and chronological age

Chronological age (CA) was calculated using the difference between the date of birth and the date of the first measurements and all the variables were taken in a one-week interval. The skeletal age (SA) was determined by using the FELS method and it was assessed by an expert using a radiograph of the pronated left hand with the fingers spread out and extended and the third finger (middle finger) aligned with the radius and the cubitus. This procedure was carried out by observing 22 bones in a total of 98 different assessment criteria. After determining the parameters in each criterion, data were entered into a program (FELShw -1.0 Software) that calculated the SA and the estimated standard error. The SA was divided by the chronological age (SA/CI Ratio) in order to provide a skeletal maturation indicator at the time of the study. A ratio above 1 indicates that the SA is advanced with respect to the CA, while a ratio less than 1 indicates a delayed SA with respect to the CA (Malina, Bouchard, & Bar-Or, 2004).

Sexual maturation

Sexual maturation was assessed through self-assessment of secondary sexual characteristics by using the stages of pubic hair following the criteria described by Tanner (1962). This procedure has been increasingly used by the scientific community in order to avoid the constraints imposed by invading the privacy of those being observed (Figueiredo, Gonçalves, Silva, & Malina, 2009b; Malina *et al.*, 2005; Malina *et al.*, 2004; Seabra, Maia, & Garganta, 2001).

Technical tests

For the technical assessment, several tests from the battery proposed by the Portuguese Soccer Federation (1986). In the ball control test, players had to juggle the ball in the air without using their arms or hands in a space of 9 m × 9 m. The performance was measured by the number of touches on the ball without letting it fall to the ground. Each player was allowed 2 attempts, and the best performance was considered for the study. In the dribbling test, the players were instructed to slalom dribble the ball around 9 cones that were positioned in a straight line and separated by a distance of 2 m. The subject was instructed to progress from the initial line to the last cone and return. The goal was to complete the course in the shortest time as possible without knocking over the cones; if the subjects knocked over the cones they had to stop and return them to the standing position. The time was recorded using a CEFISE brand photoelectric cell system. The best performance of 2 attempts was considered for the study. The kicking accuracy test consisted of a player taking 3 shots during a 1-min period at a goalpost 2.44 m in height and 7.32 m in width from a distance of 16.5 m. The goalpost was divided into 9 targets by 4 elastic bands (2 placed vertically and 2 placed horizontally), and the subjects were instructed to put the ball in the area awarding the most points. The central quadrant was worth 6 points, all lower quadrants were worth 1 point, and the other quadrants were worth 3 points. The performance was measured by adding all 3 shots. An official number 5 Trivela ball of the Soccer Federation of Minas Gerais with a pressure of 0.8 bar was used for all tests. The athletes were asked to use power when taking the shot while being watched by an observer.

In order to get an overall measure, skills were combined in one single measure. To get this value, *z*-scores were used to allow the use of different variables with different units of measurement. The final value was obtained by the sum of the three *z*-scores.

Years of sports experience

All players were interviewed in order to collect information regarding the number of years of experience in soccer practice.

Procedure for data collection

The data were collected on February and March 2011 for 2 days over a 1-week period. At the first meeting, stature, body mass, skinfolds, and technical skills were measured. At the second meeting, a radiograph of the hand and fist was taken for the SA assessment.

Statistical procedures

A descriptive statistics, namely the measures of central tendency and dispersion, was used to determine the overall aspects of various values distributions. The technical tests values were converted into a *Z*-score within each age group; the *z*-scores were inverted for the timed tests. The respective scores were added to provide a composite of technical tests, and the overall aspects of

the technical performance of each soccer player, respectively. Thereafter, multiple regression analysis was used to study the influence of factors (chronological age, biological maturation [SA/CA ratio and stage of pubic hair], body size [stature, weight, and stature × weight interaction), body proportions [seated height-stature ratio], adiposity [sum of skinfolds), and practice time) on the levels of each technical indicator (dependent variables) of young Brazilian soccer players in the under-15 and under-17 age categories. The interaction term between stature and body weight was obtained through the residue multiplication (the value of each subject minus the mean of his group); this term was used because the 2 variables tended to have a high variance overlap. This procedure was used in previous studies (Malina *et al.*, 2004). Backward selection was the solution used for including variables in the multiple regression models. All variables were inserted into the equation and sequentially removed when they met the elimination criteria. In this protocol, the variable with the lowest partial correlation to the dependent variable was first considered for removal ($p > .10$). The procedure was repeated for the other variables until only those variables that did not meet the removal criteria remained in the equation. All data analyses were conducted using the SPSS statistics 19.0 software.

Results

The biological, morphological, maturation and technical characteristics of the soccer players' participants are described in Table 1.

Table 1. Mean values (standard deviations) for temporal, morphological and related- training process, biological maturation and technical variables of young soccer players U-15 and U-17.

Predictors	Under-15 (n=74)	Under-17 (n=45)
Variables - temporal, morphological and training		
Chronological age (CA) (years)	14.35 (0.50)	16.22 (0.55)
Skeletal age (SA) (years)	15.57 (1.37)	16.89 (1.40)
SA/CA ratio	1.09 (0.09)	1.04 (0.09)
Height (cm)	167.24 (7.14)	171.2 (5.99)
Weight (kg)	56.27 (10.23)	61.07 (7.62)
Sitting height (cm)	85.45 (4.04)	88.79 (3.53)
Sitting height/ height ratio	0.51 (0.01)	0.52 (0.01)
Sum of skinfolds (mm)	44.35 (23.04)	39.14 (10.89)
Experience in soccer (years)	3.71 (2.35)	4.76 (2.63)
Stage of pubic hair (PH)		
3	8 (10.8)	----
4	51 (68.9)	25 (56.8)
5	15 (20.3)	19 (43.2)
Technical		
Ball control (# hits)	39 (34)	44 (35)
Dribbling test (s)	19.94 (2.13)	19.04 (2.24)
Kicking accuracy (points)	7.80 (3.74)	8.42 (3.16)

Table 2. Results of the multiple regression models for the under-15 category.

Dependent variables	Predictors	B	t	p	R ² adjusted (%)
Ball control	Sum of skinfolds	-0.72	-2.78	.009	14.4
Dribbling test	Sum of skinfolds	0.47	2.98	.006	19.8
Kicking accuracy	Weight	-0.19	-2.32	.027	14.4
Skill composite	Weight	-0.43	-2.09	.046	9.3

The multiple regression model results for the under-15 category are shown in Table 2. The sum of the skinfolds was negatively associated with performance in the ball control (R^2 adjusted $\approx 14\%$) and dribbling tests (R^2 adjusted $\approx 20\%$). In the accuracy test and in the composite of technical skills, body weight (negatively) was the only predictor taken into consideration. The composite of technical skills (R^2 adjusted $\approx 9\%$) was the dependent variable that recorded the lowest percentage of explained variance.

The results of the multiple regression models for the under-17 category are shown in Table 3. Years of sports experience (positively) and the SA/CA ratio (negatively) were related to performance in the ball control test, and these indicators contributed $\approx 41\%$ to the explanation of the values for this test. The SA/CA ratio was positively associated with performance in the dribbling test (R^2 adjusted $\approx 17\%$). In the accuracy test, the sum of the skinfolds was negatively associated with the respective values (R^2 adjusted $\approx 44\%$). The composite of technical skills (R^2 adjusted $\approx 54\%$) showed the highest percentage of explained variance. The sum of skinfolds (negatively), years of sports experience (positively), chronological age (negatively), and body weight (positively) were the predictors that contributed to this explanation.

Table 3. Results of the multiple regression models for the under-17 category.

Dependent variables	Predictors	B	t	p	R ² adjusted (%)
Ball control	Experience in soccer	0.55	3.52	.002	40.9
	SA/CA ratio	-0.41	-2.50	.021	
Dribbling test	SA/CA ratio	-0.46	-2.26	.036	17.0
Kicking accuracy	Height	-0.47	-2.68	.016	44.1
	Sum of skinfolds	-0.45	-2.54	.021	
Skill composite	Sum of skinfolds	-0.89	-3.59	.005	54.2
	Experience in soccer	0.45	2.20	.045	
	CA	-0.66	-2.95	.014	
	Weight	0.73	2.47	.033	

Discussion

The purpose of this study was to examine the association between morphological (stature, body weight, subcutaneous adiposity), biological maturation (sexual and skeletal maturation) and training indicators (years of soccer experience) and the technical performance of young Brazilian soccer players. A careful analysis of the present results showed that these indicators contributed to technical performance differently in the U-15 than in the U-17 category. In both categories, a negative association was observed between subcutaneous adiposity and technical performance. A justification for this finding may be the requirement for soccer players to move their bodies in diversified tasks, and indeed other study have reported similar findings (Figueiredo *et al.*, 2011). The former, in a study with Portuguese soccer players, ages 11 and 12 years, identified a negative association between adiposity and technical performance.

In the U-15 category, body weight was negatively associated with the kicking accuracy and technical skills composite. This finding may be explained by the fact that young soccer players tend to show a balanced relationship between stature and body weight until the ages of 14 or 15 years. However, an increase in body weight in the last stage of puberty changes this balanced relation as a result of a later peak velocity of growth for body mass (Malina, 2003). The results were slightly different in the U-17 category since body weight was positively associated with technical composite. This finding may be explained by the changes that tend to occur in the second half of puberty, where the peak weight velocity in general and muscle mass in particular, tends to occur at 14 or 15 years of age (Malina *et al.*, 2004).

For the U-15 category, the two variables of the explanatory model (i.e., adiposity and body weight) contributed negatively to technical performance. Adiposity also showed a negative influence on the technical performance of U-17 players. Similar results were also observed by Figueiredo *et al.* (2011) in the age categories of 11 and 12 years, but the authors found no association between this variable in 13- and 14-year-old soccer players. In this some age-group there was a negative association between body weight and performance in the test of accuracy and the composite of technical skills. However, in the U-17 category, body weight was positively associated only with the composite of technical skills. Figueiredo *et al.* (2011) found that body weight contributed positively on the dribbling test in the 13- and 14-year-old categories. Different results were observed by Malina *et al.* (2005), who found that weight did not show up as a predictor with statistical significance in the technical test. This finding in Brazilian soccer players, who are older than those sampled in the studies cited, may be explained by the fact that young soccer players tend to show a balance between stature and body weight up to 14 or 15 years old, verifying in the final period of the growth process an increase of body weight regarding stature, consequently leading to higher values in the mesomorphic component (Malina, 2003). It seems that the somatotype components can explain performance, since stature acted negatively only in the accuracy test for the U-17 category.

In this same age group, biological maturation, assessed by the skeletal age/chronological age ratio (ratio IE/IC) appears as an explanatory variable of performance skill. In the dribbling test, biological maturation was positively associated, accounting for 17% of the results. Meanwhile, ball control was negatively associated in explaining performance.

Indeed, as mentioned by Figueiredo *et al.* (2009a) and Malina *et al.* (2005), most of the variation in technique tests may not only be a result of biological maturation. In studies conducted by these authors, although the young players (14-15 years old) varied in their maturational status, they showed no significant changes in specific technical skills tasks. Other indicators which seem to influence the acquisition of a better control of movements, combined with a longer duration of sport experience in soccer and specific training methodologies, may eventually have a higher percentage of explanation in the development of technical skills. Seabra *et al.* (2001) reinforce this idea, arguing that the amount of practice and experience are critical factors in improving technical performance.

The requirement of power and speed in the dribbling test can justify the positive contribution of biological maturation. Individual differences in maturational status are associated with changes in physical fitness, and early mature boys tend to be stronger and show better results in motor tasks that require power and speed (Malina *et al.*, 2000; Malina *et al.*, 2005). Years of soccer experience indicated a positive association with the technical tests in the U-17 group. The greater the number of years of sport experience a soccer player has, the better will be his or her performance in the technical dimension. Similar results have also been observed by other authors (Figueiredo *et al.*, 2011; Malina *et al.*, 2005; Williams, 2000). In the study by Figueiredo *et al.* (2011), conducted with soccer players belonging to the age categories of under-12 and of under-14, the years of sports experience were associated positively with the technical test of older players (i.e., the under-14 group). In the under-12 category, the years of experience was positively associated with dribbling and passing the ball. Malina *et al.* (2005), in a study of soccer players ages 13 to 15, also identified a positive association between sport experience and performance in technical tests. These results suggest a two-fold consideration: the importance of children gaining experience in soccer as early as possible, and the importance of patience among coaches and other agents to wait for the full acquisition of soccer skills in order to avoid a premature specialization.

The results of the present study should be considered with certain limitations. First, the study was cross-sectional, which limits conclusions regarding causal relationships between morphology, biological maturation and technical performance. A second limitation is related to the study sample. Our sample only included U-15 and U-17 soccer players from the state of Minas Gerais (city of Juiz de Fora), which prevents us from generalizing the findings to other Brazilian soccer players. The third limitation is related to the indicators that were analyzed. This study has only tested morphological and biological maturation indicators, and it is necessary to analyze different predictors such as those driven by psychological and tactical dimensions.

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