Original Article

What are the implications of controlling anthropometric variables when comparing technical skills and physical fitness in young soccer regional players?

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Abstract:

The aim of this study was to compare performance in technical skills and physical attributes after controlling for body mass and height in young soccer regional players. The sample was composed of 68 young soccer players (12.83±2.43 years). Physical fitness was assessed using the Counter Movement Jump, Yo-Yo Intermittent Recovery Test 1, and Speed 30 m tests. Regarding technical skills, the General Soccer Ability Skill Test Battery was applied through three tasks: dribbling, shooting, and passing. Multiple Linear Regression (stepwise method) was adopted to estimate the relative contribution of body mass and height to physical and technical performance. ANCOVA followed by Bonferroni adjustments were used to compare performances of young players across different age groups, controlling for height and body mass ($P < 0.05$). Results indicated that body size was a predictor of aerobic power ($R^2 = 0.55$), speed ($R^2 = 0.60$), and dribbling ($R^2 = 0.30$) in young players. Even controlling for body size variables, the Bonferroni adjustments used in the ANCOVA identified significant differences between some categories in the Yo-Yo Intermittent Recovery Test ($F_{(3,62)} = 12.405$; $P < 0.001$), speed ($F_{(3,62)} = 6.983$; $P < 0.001$), counter movement jump ($F_{(3,62)} = 5.768$; $P = 0.002$), dribbling ($F_{(3,62)} = 6.130$; $P = 0.001$), and shooting ($F_{(3,62)} = 4.372$; $P = 0.007$). Passing was shown to be controlled by body mass and height. It can be concluded that body mass and height have an impact on physical fitness and technical skills in young soccer players and can be used as covariates to control comparisons between players from different age groups, especially U-11 players when compared to older players.

Key words: Adolescent, soccer, physical fitness, body size.

Introduction

To reach success in soccer, a series of competences must be developed by players. Physical fitness, technical-tactical indicators, and psychological domains have been reported in the literature as central components to achieve excellence in this sport. Recently, researchers have investigated the contributions of different factors to predict success in adult and adolescent players, as well as the relationships between them (Deprez et al., 2015; Praça et al., 2015). Figueiredo, Gonçalves, Coelho-e-Silva, and Malina (2009) compared characteristics of youth soccer players who dropped out, persisted, or moved up to a higher level from soccer training. Results indicated that elite players were skeletally older, larger in body size, and achieved better scores in functional capacities and technical skills than players who dropped out, which suggests the importance of growth and maturational indicators to remain in an elite team.

Monitoring of variables related to growth and maturation in young players is fundamental, since within the same chronological age group, some players can present advantages in physical performance according to biological age. Players late in this process tend to achieve lower results in tests when compared to players advanced in biological maturation (Jones, Hitchen & Stratton, 2000; Figueiredo et al., 2009; Figueiredo, Coelho-e-Silva & Malina, 2011). Some studies have been performed with young players considering the maturational process to analyze performance indicators (Philippaerts et al., 2006; Vandendriessche et al., 2012; Valente-dos-Santos et al., 2014). Malina, Bouchard and Bar-Or (2009) reported that physical fitness is influenced by body size, especially as mass and volume of the heart grow proportionally to body mass. Malina et al. (2005) and Figueiredo et al. (2011) presented different predictors of functional capacities and technical skills in young athletes, which included body size, age, experience, and maturity, among others.

Although this scenario is known, few studies have actually controlled for the effects of variables related to growth and maturation processes when comparing different chronological age groups (Ritti-Dias et al., 2007; Borges, Avelar & Rinaldi, 2015; Gouvea et al., 2016). This seems to be important since performance in physical

fitness and technical tests could be under or overestimated according to maturational process. In addition, the majority of investigations have focused on high level athletes (Malina, Ribeiro, Aroso & Cumming, 2007; Russell & Tooley, 2011). It is known that the performance results of regional players tend to be underestimated when compared with national players (Chibane, Hautier, Gaudino, Massarelli & Mimouni, 2008). It is important to understand the behavior of physical and technical dimensions in young regional soccer players after controlling for body size. This information could be used by coaches to more adequately plan training content, considering the characteristics of the player group. Thus, the aim of this study was to compare performance in technical skills and physical attributes after controlling for the effects of body mass and height on these variables.

Material & methods

Participants

In total, 140 young male soccer players, participants of a soccer extension project offered by the State University of Maringa, were pre-selected to participate in the study. The following inclusion criteria were adopted: (a) being enrolled in the extension project; and (b) having a Consent Form signed by parents or guardians for participation in this study. The following exclusion criteria were adopted: (b) not attending the evaluations; (b) the presence of any muscular or skeletal injuries; and (c) attendance at training sessions of less than twice a week. The final sample consisted of 68 young soccer players, being 22 players from the Under 11 - U-11 (10.1 ± 1.3 yrs), 14 players from the Under 13 - U-13 (12.1 ± 0.6 yrs), 21 players from the Under 15 - U-15 (14.3 ± 0.7 yrs), and 11 players from the Under 17 - U-17 (16.3 ± 0.6 yrs) categories. The project was approved by the local Institutional Review Board (Opinion 653.698).

Test protocol

Anthropometric measurements of body mass, height, and sitting height (SH) were performed. Body mass was measured on a calibrated digital scale, with a maximum load of 180 kg and accuracy of 0.1 kg. Height was determined on a portable stadiometer with a precision of 0.1 cm. For this evaluation, the subject was required to be barefoot and wearing only shorts. Height measurements were determined to the nearest 0.1 cm. To measure the "sitting height", a bench was added to the stadiometer that allowed the player to position the knees forward, forming a 90° hip angle with the trunk, without the feet touching the ground (Gordon, Chumlea & Roche, 1988). Thus, the length of the lower limbs was obtained by subtracting the "sitting height" from the height.

Using anthropometric measurements, the relative indicator of somatic maturity (peak height velocity - PHV) was calculated through the interaction between leg length, age, body mass, and height measurements (Mirwald, Baxter-Jones, Bailey & Beunen, 2002). This method allows the distance between current age and the period at which maximum growth in stature is achieved during adolescence to be obtained.

The evaluation of player aerobic performance was accomplished through the Yo-Yo Intermittent Recovery Test 1. This test includes a series of 20m races with a pre-established cadence regulated by an audio sound, with 10 second intervals (Krustrup et al., 2003). The objective of the test is to travel the pre-established distance, as far as possible, until the player cannot maintain the required speed.

Muscle strength of the lower limbs was estimated based on vertical jumps, as proposed by Bosco, Luhtanen and Komi (1983) using the Counter-Movement Jump (CMJ). The jump was evaluated on a jump platform - EMG System Brasil[®]. The athletes performed the vertical jump twice and only the best performance was computed. The distance of the jump was estimated based on an equation that considers an interaction between flight time and gravity, proposed by Bosco et al. (1995). Speed 30 m was assessed using a photocell system. Each player ran twice and the best performance was considered as the final score (Eston & Reilly, 2013).

With regard to technical skills, the General Soccer Ability Skill Test Battery proposed by Mor and Christian (1979) was used. The main purpose of this battery is to evaluate performance of players in passing, shooting on goal, and dribbling. In the dribbling test, players must run with the ball at a previously known trajectory. In the passing and shooting on goal, the players were requested to shoot at previously established targets.

Statistical analysis

Normality of data was tested by the Kolmogorov-Smirnov test. To compare variables according to different game categories, ANOVA One Way followed by Tukey post hoc was used. Multiple Linear Regression was used to estimate the relative contribution of body mass and height (independent variables) to physical and technical performance (dependent variables). The stepwise method was adopted to select or remove both variables in the models created, using the criterion for removal of $P > 0.05$. Analysis of Covariance (ANCOVA) was performed to evaluate the influence of different game categories (independent variable) on physical fitness and technical indicators (dependent variables), controlling for body mass and height (covariates). Subsequently, Bonferroni adjustments were used to identify differences between age groups in ANCOVA. ANCOVA

assumptions of homogeneity were validated by the Levene's test and homogeneity of slopes was assessed according to Maroco (2014). The intra-examiner technical error of measurement (TEM), obtained through the method of the differences, for the anthropometric variables was below 1.0%, being: 0.1% for body mass, 0.3% for height, and 0.5% for sitting height, according to the methodology of Norton and Olds (2004). Data were processed using SPSS 20.0. The level of significance was set at 5%.

Results

The anthropometric indicators, physical fitness, and some technical indicators presented a positive evolution in function of age categories using ANOVA, as described in Table 1.

Table 1. Comparison of anthropometric, technical and physical variables of players from different age categories

Variables	U-11 (n=22) M±SD	U-13 (n=14) M±SD	U-15 (n=21) M±SD	U-17 (n=11) M±SD	F	P
Age (yrs)	10.14±1.33	12.11±0.62 ^a	14.34±0.67 ^{ab}	16.26±0.57 ^{abc}	133.90	<0.001
Body mass (kg)	37.16±11.38	47.05±10.86 ^a	59.51±11.76 ^{ab}	60.19±7.5 ^{ab}	19.07	<0.001
Height (cm)	141.46±10.24	152.03±8.69 ^a	166.99±7.86 ^{ab}	171.13±4.48 ^{ab}	45.75	<0.001
SH (cm)	73.42±4.49	77.99±4.48 ^a	85.82±4.45 ^{ab}	87.69±3.08 ^{ab}	42.55	<0.001
PHV (years)	-3.04±1.01	-1.62±0.76 ^a	0.42±0.87 ^{ab}	1.58±0.58 ^{abc}	94.64	<0.001
Dribbling (sec.)	22.96±7.07	19.80±3.11	16.52±2.19 ^a	14.63±1.35 ^{ab}	11.45	<0.001
Passing (score)	3.04±2.03	4.00±2.14	4.19±1.36	5.00±1.78 ^a	3.08	0.033
Shooting (score)	35.81±17.00	38.71±20.39	62.47±27.91 ^{ab}	57.81±17.62 ^a	7.02	<0.001
YYIRT1 (m)	263.63±115.57	360.00±154.52	708.57±207.51 ^{ab}	800.00±218.35 ^{ab}	37.63	<0.001
Speed (m/s)	5.55±0.60	5.90±0.53	6.69±0.42 ^{ab}	7.09±0.54 ^{ab}	28.77	<0.001
CMJ (cm)	19.05±4.23	17.57±3.71	24.66±4.61 ^{ab}	27.76±4.33 ^{ab}	17.84	<0.001

Note: ^aSignificant difference for U-11; ^bSignificant difference for U-13; ^cSignificant difference for U-15.

As described in Table 2, body mass and height helped to explain, together, 60% of the variability of speed and 55% of contribution to aerobic power, represented by the Yo-Yo Intermittent Recovery Test. With regard to technical tests, only dribbling showed to be influenced by body mass and height. Players that present higher body height tended to spend less time dribbling ($\beta = -1.07$). Passing and shooting were removed from the equation as they were not predicted by independent variables.

Table 2. Regression models to analyze the relative contribution of body mass and height to physical and technical variables in young soccer regional players

Dependent Variable	Independent Variable	β	P	R ²	Adjusted R ²	P
YYIRT1	Body Mass	-0.62	<0.01	0.56	0.55	<0.001
	Height	1.21	<0.01			
Speed	Body Mass	-0.72	<0.01	0.61	0.60	<0.001
	Height	1.29	<0.01			
CMJ	Height	0.56	<0.01	0.31	0.30	<0.001
Dribbling	Body Mass	0.75	<0.01	0.34	0.32	<0.001
	Height	-1.07	<0.01			

Note: YYIRT1 = Yo-Yo Intermittent Recovery Test 1; CMJ = Counter Movement Jump.

Analysis of Covariance indicated that performance in the YYIRT1, Speed, and CMJ were influenced by age category after controlling for the effects of body mass and height on this variable ($F_{(3,62)}=12.405$; $P<0.001$, $F_{(3,62)}=6.983$; $P<0.001$ and $F_{(3,62)}=5.768$; $P=0.002$) respectively, as shown in Figure 1. The Bonferroni post-hoc identified significant differences in the YYIRT1 and speed between categories, where the U-17 and U-15 tended to present high values of physical fitness even controlling for effects of body size. It was identified that the U-13 category differed from the U-15 and U-17 in CMJ. Regarding technical skills, an influence of game category was observed on dribbling ($F_{(3,62)}=6.130$; $P=0.001$) and shooting ($F_{(3,62)}=4.372$; $P=0.007$), after controlling for effects of body size.

Figure 1. Analysis of Covariance (ANCOVA) comparing physical fitness and technical indicators between different age categories after controlling for effects of body mass and height.
Note: 11 = significative difference for under-11; 13 = significative difference for under-13. $P < 0.05$.

Discussion

The aim of this study was to compare the performance in technical skills and physical fitness after controlling for the effects of body mass and height on these variables. The main findings showed that body mass and height are predictors of functional capacity and dribbling and when they were added as covariates in the comparisons between different age groups, the U-11 players achieved similar performances in passing and the counter movement jump when compared with U-15 and U-17 players and shooting compared to U17 players.

Regression models applied in Table 2 show that body size appears as a significant source of variation in physical fitness performance, since body mass and height together explained 60% of the variability of speed and 55% of aerobic power. In addition, height contributed approximately 30% to strength of lower limbs. When evaluating U-13 and U-15 players, Cunha et al. (2017) verified that body height alone was able to predict the majority of variation in lower limb strength and speed, explaining 87% and 83% respectively. Figueiredo et al. (2011) evaluated players aged 11 to 14 years, and found that body size similarly influenced strength, speed, and aerobic capacity. Regarding technical skills, only dribbling was demonstrated to be influenced by body size

dimensions, where body mass and height together explained 32% of performance variability. Passing and shooting were not predicted by any independent variables analyzed. In agreement with other studies, body growth indicators do not seem to influence, on a large scale, the performance of specific soccer skills (Malina et al., 2005; Vandendriessche et al., 2012). In addition, technical-tactical dimensions are more difficult to measure when compared to functional capacities, since they are highly influenced by sports experience, motor development, and other factors associated with training, sometimes justifying the fact that less physically developed players in some cases achieve better technical performance indices within the same age group (Malina et al., 2005; Figueiredo et al., 2011). Thus, it is recommended that clubs and federations involved with youth soccer formation focus attention not only on physical fitness but also on qualities related to technical-tactical domains.

To minimize the effects of body mass and height on the analyzed variables, for technical skills, the ANCOVA results indicated that U-11 athletes achieved similar scores in passing and shooting to U-17 players. At the same time, the U-13 category did not differ in dribbling time from U-15 or U-17 players. These results can be explained since the battery used to assess technical skills requires physical attributes to execute all movements and body size is related to physical performance (Borges et al., 2017). In this way, coaches should take anthropometric variables into account when using the General Soccer Ability Skill Test Battery to assess youth players, especially those players late in the maturational process.

Regarding physical fitness, only the vertical jump (CMJ) seems to be controlled by body size. The U-11 players reached similar scores in the CMJ to the U-15 and U-17 groups. According to Figueiredo et al. (2011), biological maturation is a predictor of and influences performance in vertical jumps in young players. As can be inferred, body mass and height are intimately related to maturational status which helps to explain the control presented in the ANCOVA.

Contrary to expectations, aerobic power (YYIRT1) and speed showed that even controlling for the effects of body size to compare teams, the U-11 and U-13 categories still presented lower values than the U-15 and U-17. Thus, other factors could influence biological indicators between age groups such as quality and amount of training, methodology adopted, and chronological age, among others (Malina et al., 2005; Figueiredo et al., 2011).

Collectively, these findings suggest that body structure must be taken into account, since it exerts a significant influence on the modality specific conditioning variables. Aspects such as chronological age, biological maturation, and other similar characteristics should be combined with statistical models that reduce the estimation error (Cunha et al., 2017). Thus, as practical applications of these results, it is recommended that clubs and federations involved with young soccer players use information provided by anthropometric dimensions with the aim of understanding and interpreting the impact of growth processes on physical and technical results, since height and body mass are variables commonly used to monitor growth of adolescents (Carvalho et al., 2011).

Conclusions

The results of this study revealed that body mass and height can be used as covariates to control comparisons between regional players from different age groups, especially U-11 players when compared to older players. Given the importance of physical and technical domains for sport, clubs and federations can use these variables to understand the real level of performance after eliminating the influence of body size.

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