Original Article

Age-related trends in anthropometry and jump and sprint performances in elite soccer players from 13 to 20 years of age: A cross-sectional study

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ABSTRACT

The aim of this investigation was to determine age-related trends for anthropometric and physical variables in elite young soccer players. For this purpose, a total of 114 young male soccer players from a high-performance soccer academy participated in this investigation. Anthropometric and physical variables (countermovement jump, 6×40 m shuttle run test, 2×11 m slalom test with the ball) were determined. Results. Body height (U15<U17~U20; p<0.01) and body mass significantly increased (U15<U17<U20; p<0.01) while body fat decreased with age (U15~U17>U20; p<0.01). However, the relationships of these variables with age were explained by curvilinear polynomial equations with a tendency for plateauing at ~17 years of age. There were also age-based differences in maximal running velocity (U15<U17<U20; p<0.01), running velocity with ball (U15<U17~U20; p<0.01) and jump height (U15<U17<U20; p<0.01). The relationships of the physical variables with age were explained by curvilinear polynomial equations with plateaus starting at~17 years of age. In young soccer players, the evolution of individual anthropometric and physical condition is strongly related to player's age as part of the qualitative adaptations that accompany growth. However, the growth

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process cannot be explained by linear models because most of the variables reached a plateau when players were 17 years of age. **Keywords:** Growth; Team sports performance; Repeated sprint ability; Athlete.

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INTRODUCTION

The ability to perform power-based actions (such as jumps) and high-speed running bouts (such as sprints) is an essential fitness component for successful participation in several team sports (Mendez-Villanueva et al., 2011). In these sports, it is not only essential to produce high-power jumps and quick runs and movements, it is also necessary to reproduce the performance of these high intensity actions in subsequent movements because repeated-sprint ability has been deemed to be a main player attribute for match performance (Girard, Mendez-Villanueva, & Bishop, 2011; Unnithan, White, Georgiou, Iga, & Drust, 2012). Although there has been an increase in knowledge and interest in the ability to sprint in adult team sport players (Girard et al., 2011), there is still little information about the evolution of these high-intensity actions in highly trained young team sport athletes (Mujika, Spencer, Santisteban, Goiriena, & Bishop, 2009), despite this information being crucial for an appropriate and relevant selection process of young athletes.

The human body undergoes important age-related changes during childhood and adolescence that influence the locomotor system and motor function, ultimately affecting physical performance in several sports disciplines, such as soccer (Malina, Bouchard, & Bar-Or, 2004). Regarding speed achieved during running, the growth process can be observed in the continuous improvements in sprint speed values with age (Papaiakovou et al., 2009), while the ability to repeat sprints seems to improve less with increasing age (Mujika et al., 2009). Although the improvements in sprint performance with age have been related to the higher dependence on anaerobic metabolism (Hebestreit, Mimura, & Bar-Or, 1993; Zafeiridis et al., 2005) and the higher rate of ATP/phosphocreatine use and lactate production with age (Zanconato, Buchthal, Barstow, & Cooper, 1993), other investigations have determined that the evolution of body anthropometry greatly affects sprint performance in young soccer players (Malina et al., 2004; Mujika et al., 2009). Physical characteristics such as body height and body mass have been reported to be determinants of sprint running performance (Wong, Chamari, Dellal, & Wisloff, 2009) while a plateau in sprinting ability might occur at 14-15 years of age (Mujika et al., 2009) coinciding with the peak height and peak body mass velocity of young soccer players (Philippaerts et al., 2006).

Traditionally, anthropometric and fitness assessments determine in part the selection process of elite soccer and thus soccer players' chances of proceeding to higher achievement levels (le Gall, Carling, Williams, & Reilly, 2010). Still, elite and non-elite youth soccer competitions are arranged by age-groups, and youth soccer teams typically include players with a difference of two years of age. The chronological differences in age among players of the same team might imply considerable differences anthropometry and physical conditioning, especially at an early age. Because of this system of two-year age categories, it has been proven a bias in who is chosen and who is discarded in the selection process of elite young soccer players, facilitating higher levels of achievement for older players or those players born at the beginning of the year (Gutierrez Diaz Del Campo, Pastor Vicedo, Gonzalez Villora, & Contreras Jordan, 2010). This phenomenon, known as relative age effect, has been proven in a variety of sport disciplines (Wattie, Schorer, & Baker, 2015) and can impact the likelihood of reaching professional football categories (Del Coso et al., 2014). To avoid this bias, it would be helpful the establishment of normalized values for anthropometric and physical variables in elite youth soccer that allows the comparison of soccer players with differences in age. In addition, precise information about the variations experimented in these variables in players with the same birth-year could reduce the relative age effect in soccer.

While most of the age-related physical and anthropometric studies have used data on young soccer players grouped by categories (including players within one or two years of age), and with low age ranges that did not cover the whole growth process (Valente-Dos-Santos et al., 2012) there is no information regarding precise age-related trends in anthropometry and sprint-based performance in elite young soccer players. For this reason, the purpose of this investigation was to determine the age-related variations in anthropometric and physical characteristics of players from the development academy of a professional soccer club. For this investigation, we selected a cross-sectional approach by comparing anthropometric and physical variables among soccer players from 13 to 20 years of age and by using their exact chronological age. We hypothesized that differences in anthropometry and physical conditioning in the teams of the soccer academy will be related to soccer players age in a curvilinear fashion, with plateaus in these variables reached in soccer players of >15 years of age. We also hypothesised a high variability in anthropometric and physical variables for a given age in these elite, young soccer players.

MATERIAL AND METHODS

Design

A cross-sectional and correlational experimental design was used in this investigation. All players underwent the same testing under the same experimental conditions that included measurements in a regular soccer facility (21.5 ± 0.5 ºC of dry temperature and 45.3 ± 16.2 % of relative humidity). The measurements were obtained in the middle of the training season and two or three days after the preceding competitive game to allow physical recovery. During the months previous to this investigation, all players exclusively trained in the soccer academy and followed a similar training program designed by the staff of the academy and under the supervision of their respective coaches. The physical testing was carried out after a standardized 25-min warm up that included low-to-medium intensity running, submaximal and maximal accelerations and sprints and drills and shots with the ball. The physical testing was performed by the same experimenters for all individuals and the tests were carried out on a natural grass soccer field with the players wearing soccer boots (to replicate competitive playing conditions).

Participants

A total of 114 young male soccer players (aged between 13.0 and 20.0 years) were voluntarily recruited for the investigation. All players pertained to the high-performance soccer academy of a First-Division club in Spain, had soccer training experience of at least three years and had trained an average of 14 h/week, including a competition game, during the previous year. Only field players were tested for this investigation. The players were grouped on the basis of their birth-year according to the system of two-year age categories established by the Royal Spanish Soccer Federation: under 15 (U15 = 41 soccer players), under 17 (U17 = 36 soccer players) and under 20 (U20 = 37 soccer players). However, the exact chronological age of each player was used to increase the sensibility of the age-trends analysed in this investigation. All participants and their parents/guardians received written and verbal information regarding the nature of this investigation and provided written informed consent. The study was approved by the Camilo Jose Cela University Ethics Committee in accordance with the latest version of the Declaration of Helsinki.

Procedures

Two days before the experiments, participants were instructed to avoid caffeine-containing products and refrained from strenuous exercise. Training and diet were standardized for 24 hours before the experimental trial with the assistance of the technical staff of the team to assure that glycogen stores were replenished before the testing. The compliance of these standardizations was verified using self-reported diaries. Participants arrived at their habitual training facilities at 16.00, three hours after their last meal, that included 4 g/kg of carbohydrates and 7 mL/kg of water. On arrival, body mass (± 0.1 cm) and body height (± 0.05 kg) were measured (Seca 285, Germany) and these data were used to calculate the individual body mass index. Body fat percentage was estimated using segmental bioimpedance (BC-418, Tanita, Japan) following appropriate standardizations and using the standard built-in prediction equations for children (Sung, Lau, Yu, Lam, & Nelson, 2001).

After these measurements, participants warmed up and performed two countermovement vertical jumps (CMJ) for maximal height on a force platform (Quattrojump, Kistler, Switzerland) with 1 min of recovery between repetitions. For this measurement, the participants flexed their knees, jumped as high as possible while maintaining their hands on their waist, and landed with both feet. The highest jump was used for statistical analysis. Then participants performed a maximal velocity 2 × 11 m slalom test with the ball that consisted of running as fast as possible while dribbling around previously set cones with constant changes of direction (Milanovic, Sporis, Trajkovic, James, & Samija, 2013). For this measurement, each participant started the test with his feet behind the start line while six cones were set up 2-m apart (the first cone was placed 1 m away from the start line). On command, players ran at maximal velocity from point to point (the first cone had to be passed on their right-hand side) while dribbling around the cones with the ball. The players ran with the ball until they reached the last point, made a 180° turn and continued the slalom back to the start line. The time taken to complete this test was measured with an infrared photocell system (±0.01 s; DSD, Laser System, Spain) and running velocity was calculated as the distance covered in the test divided by the time employed to complete the test. Two attempts at this test were performed with 1 min of recovery while the repetition with the highest velocity was used for statistical analysis. After 5 min of recovery participants performed a 6 × 40 m (20 m + 20 m with change of direction) repeated sprint ability test, with 20 s of recovery between repetitions, as previously described (Baldi, Silva, Buzachera, Castagna, & Guglielmo, 2017). On command, players ran at maximal velocity from the start line to the end line (from 0 to 20 m), made a 180° turn and continued running at maximal velocity back to the start line (from 20 to 0 m). After 20 s of active recovery, the participants repeated the sprint with the change of direction. The time taken to complete each 20 + 20 m bout was measured with infrared photocells while the running velocity for each repetition was calculated as described for the slalom test. The highest velocity reached in any of the six repetitions was considered as maximal running velocity while the average running velocity for all six repetitions was considered for statistical analysis. The fatigue attained in this test was measured as percent sprint decrement using the following equation:

$$((\text{total sprint time}/\text{ideal sprint time}) \times 100) - 100,$$

as previously indicated (Mujika et al., 2009). Ideal sprint time was considered as the best sprint time, usually the first sprint, multiplied by 6.

Analysis

All the variables were initially checked for normality using the Shapiro-Wilk test and all of them presented a normal distribution. The comparison between the three groups (U15 *vs* U17 *vs* U20) was performed using a one-way ANOVA. When the ANOVA showed a significant group-effect, between group differences were allocated using the Bonferroni *post-hoc* test. The relationship between age and the remaining variables measured in this investigation was assessed computing linear and polynomial correlations in order to determine the line for the best fit of the data. In all the variables measured, the line for the best fit was represented as a second order polynomial function. For each significant difference found in this study, we have calculated the effect size (ES) as proposed by Cohen. The criteria to interpret the magnitude of the effect size were: ≤ 0.2 trivial, > 0.2 to 0.6 small, > 0.6 to 1.2 moderate, > 1.2 to 2.0 large, > 2.0 very large (Batterham & Hopkins, 2006). The data were analysed with the statistical package SPSS version 20.0 (SPSS Inc., Chicago, IL). The significance level was set at $p < 0.05$. Data are presented as mean ± SD for each group of young soccer players.

RESULTS

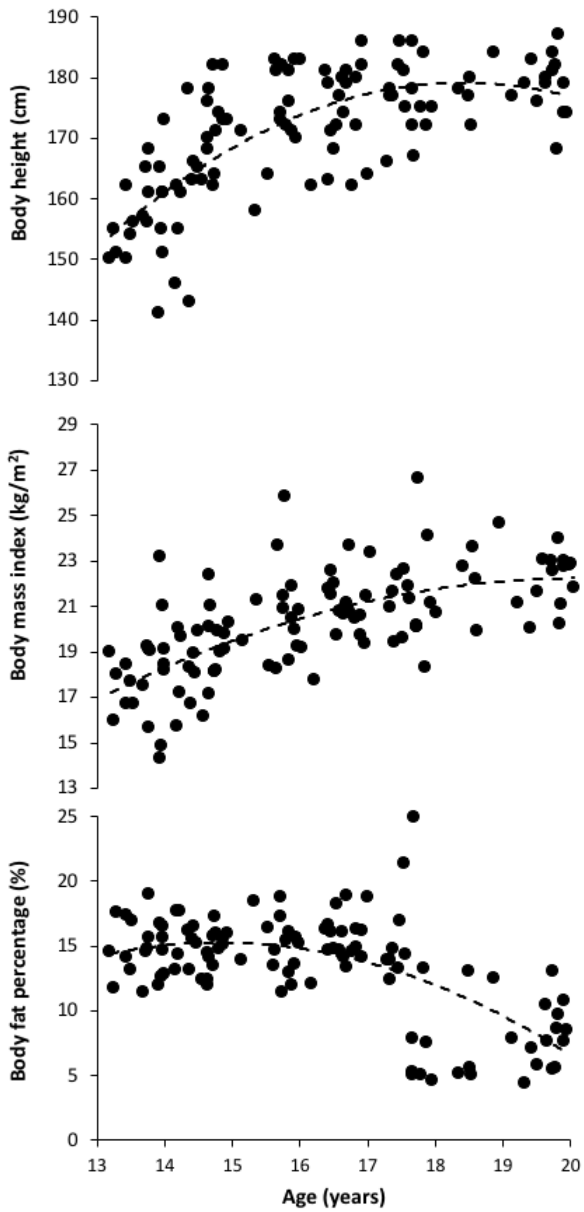
As expected, there were significant differences in age among the three groups of soccer players (Table 1, U15 < U17 < U20; $p < 0.01$). Body height was significantly lower in U15 than in U17 and U20 ($p < 0.01$) and there were significant differences among the three groups in body mass (U15 < U17 < U20; $p < 0.01$). Similarly, there were between-group differences for body mass index in all pairwise comparisons (U15 < U17 < U20; $p < 0.01$). Body fat percentage was lower in U20 than in the remaining two groups (U20 < U15 ~ U17; $p < 0.01$).

Table 1. Body and physical variables in elite young male soccer players under 15 (U15), under 17 (U17) and under 20 (U20) years.

Variable (units)	**U15**	**U17**	**U20**	**U15 vs U17**	**U15 vs U20**	**U17 vs U20**	***p* value**
n	41	36	37	-	-	-	-
Age (yr)	14.2 ± 0.5 (13.2-14.9)	16.2 ± 0.5* (15.1-16.9)	18.5 ± 1.0*† (17.0-20.0)	3.9 (very large)	8.5 (very large)	4.8 (very large)	< 0.01
Body height (cm)	163 ± 10 (141-182)	175 ± 7* (158-186)	177 ± 5* (164-187)	1.2 (moderate)	1.8 (large)	0.6 (small)	< 0.01
Body mass (kg)	49.3 ± 9.8 (28.4-69.3)	63.6 ± 8.4* (46.6-85.4)	68.9 ± 6.8*† (56.1-83.4)	1.5 (large)	2.0 (large)	0.4 (small)	< 0.01
Body mass index (kg/m^2)	18.4 ± 1.9 (14.3-23.2)	20.7 ± 1.7* (17.8-25.8)	21.9 ± 1.7*† (18.3-26.6)	1.2 (moderate)	1.8 (large)	0.7 (small)	< 0.01
Body fat (%)	14.9 ± 1.9 (11.4-18.9)	15.2 ± 1.9 (11.4-18.9)	10.2 ± 4.9*† (4.4-24.9)	0.2 (trivial)	2.5 (very large)	2.6 (very large)	< 0.01
Maximal running velocity at RSA (km/h)	19.3 ± 0.7 (17.4-20.8)	20.5 ± 0.6* (18.5-21.6)	20.9 ± 0.5*† (19.8-21.7)	1.7 (large)	2.3 (very large)	0.6 (small)	< 0.01
Average running velocity at RSA (km/h)	18.5 ± 0.7 (16.4-20.0)	19.8 ± 0.6* (17.9-20.7)	20.0 ± 0.5* (18.8-20.8)	1.9 (large)	2.1 (very large)	0.2 (trivial)	< 0.01
RSA fatigue (%)	4.4 ± 1.3 (1.7-7.2)	3.7 ± 1.2* (1.5-6.6)	4.8 ± 1.3† (2.5-7.1)	0.5 (small)	0.3 (small)	0.9 (moderate)	<0.01
Peak running velocity with the ball in the slalom test (km/h)	8.3 ± 0.5 (7.3-9.3)	8.6 ± 0.6* (7.5-10.2)	8.9 ± 0.6* (7.4-9.7)	0.6 (small)	1.1 (moderate)	0.4 (small)	< 0.01
Jump height (cm)	29.2 ± 4.7 (19.0-43.0)	32.7 ± 4.6* (23.9-42.4)	37.8 ± 3.5*† (29.2-43.5)	0.7 (moderate)	1.8 (large)	1.1 (moderate)	< 0.01

Data are mean ± SD (range), together with pairwise effect sizes. RSA = repeated sprint ability
(*) Different from U15 at p < 0.05; (†) different from U17 at p < 0.05

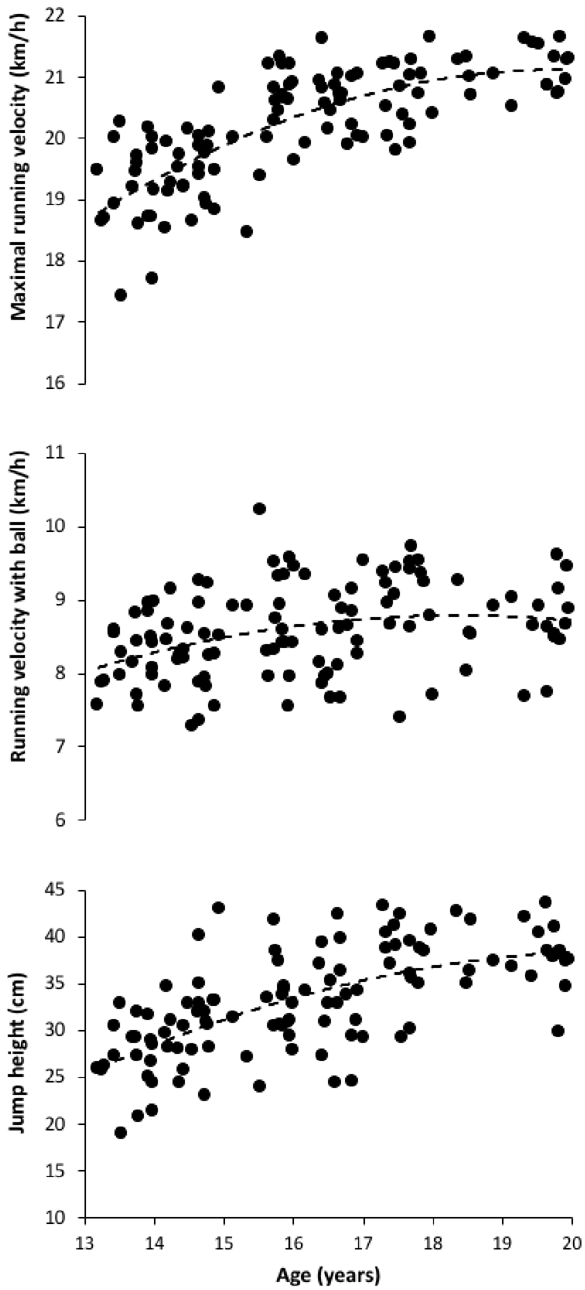
Figure 1 depicts the growth trends for body characteristics in the study sample. Participants' body height increased with age in a curvilinear fashion (r = 0.72; $p < 0.01$) although a plateau was evident after 17 years of age. Body mass and age were also correlated in a polynomial fashion (r = 0.77; $p < 0.01$). As a result of these two trends (e.g., body height and body mass), players' body mass index increased with age (r = 0.67; $p < 0.01$). However, body fat percentage was negatively correlated with age (r = -0.63; $p < 0.01$) although a higher trend for a reduction in body fat percentage was found after 16-17 years of age.



Age significantly correlated with body height (r = 0.72; p < 0.01) body mass index (r = 0.68; p < 0.01) and body fat percentage (r = -0.68; p < 0.01).

Figure 1. Growth trends for body height, body mass index and body fat percentage in elite young soccer players (from 13 to 20 years old)

There were significant differences in the maximal running speed reached during the repeated sprint test (Table 1, U15 < U17 < U20; *p* < 0.01). However, average running speed in this test was only lower in U15 respect to the other two groups (*p* < 0.01). The fatigue experienced during the repeated ability sprint test was lesser in U17 when compared to U15 and U20 (*p* < 0.05). The running velocity obtained with the ball in the slalom test was lower in U15 in comparison to U17 and U20 (*p* < 0.01) without differences between these last two groups. There were significant differences in the jump height obtained during the countermovement jump (U15 < U17 < U20; *p* < 0.01). Figure 2 depicts the growth trends for the physical variables measured in this investigation. The maximal running speed measured during the repeated sprint test increased along with age in a curvilinear fashion (r = 0.77; $p < 0.01$). In the same way, average running speed and age were significantly correlated (r = 0.75; $p < 0.01$). However, running fatigue during the repeated sprint ability test was not correlated with age (r = 0.01; *NS*). The association between running velocity with the ball and age was less strong although still significant (r = 0.34; $p < 0.01$). Finally, jump height and age were also correlated in a curvilinear fashion (r = 0.65; $p < 0.01$).



Age significantly correlated with maximal running speed (r = 0.77; p < 0.01), running velocity with the ball (r = 0.34; p < 0.01) and jump height (r = 0.65; p < 0.01).

Figure 2. Growth trends for maximal running velocity during a repeated sprint ability test, running velocity with the ball in the slalom test and jump height during a countermovement jump in elite young soccer players (from 13 to 20 years old)

Table 2. Polynomial equations that explain the line for the best fit when correlating age (X-axis) and anthropometric and physical variables (Y-axis)

Variable (units) for Y-axis	***Age (years) for X-axis***
Body height (cm)	$y = -0.9257x^2 + 34.096x - 134.75$
Body mass (kg)	$y = -0.8391x^2 + 32.204x - 238.29$
Body mass index (kg/m^2)	$y = -0.1077x^2 + 4.3148x - 20.974$
Body fat (%)	$y = -0.3253x^2 + 9.6409x - 56.163$
Maximal running velocity at RSA (km/h)	$y = -0.0532x^2 + 2.1096x + 0.2196$
Average running velocity at RSA (km/h)	$y = 0.0252x^2 - 0.9612x + 16.293$
RSA fatigue (%)	$y = 0.0589x^2 - 1.9017x + 19.37$
Peak running velocity with ball in the slalom test (km/h)	$y = -0.0266x^2 + 0.9763x - 0.1698$
Jump height (cm)	$y = -0.2124x^2 + 8.8836x - 54.274$

DISCUSSION

The aim of this investigation was to determine age-related trends for anthropometric and physical variables in highly trained young soccer players by using a more sensible and wide-ranging analysis than previous investigations (Mendez-Villanueva et al., 2011; Mujika et al., 2009). The main outcomes of this cross-sectional investigation were: a) changes in anthropometric and physical conditions experienced by young male soccer players were highly correlated with player's age but in a curvilinear rather than lineal fashion. The shape of these correlations indicates a strong tendency for plateauing in anthropometric and physical variables in soccer players of approximately 17 years of age; b) highly trained soccer players are assumed to increase body height, body mass and body mass index until 17 years of age and experience a progressive reduction in body fat percentage after that age; c) maximal running velocity increased along with soccer players age and category but the ability to repeat sprints seemed to be not related to player's age. Moreover, running velocity with the ball seemed to be less affected by age than maximal running speed and jump height, likely because this variable is highly influenced by the player's skill with the ball. All this information might be valuable for coaches of soccer academies in order to compare the anthropometric and physical condition during childhood and adolescence of soccer players to these normalized values obtained in a high-performance soccer academy. The sensibility provided by this analysis allows the calculation of the "expected" values for a given exact age (Table 2) which in turn might help to reduce the relative age effect in the selection process of soccer. Finally, these data can also be used to eliminate the confounding effect of age during the long-term training plans, improving the assessment of the efficacy of specific training protocols.

Physical performance is influenced by biological growth during childhood and adolescence and thus, performance can be greatly affected by the player's age and maturation status (Malina et al., 2004). Age-related effects can influence several physical variables such as, cardiorespiratory and muscular endurance, explosive strength, running speed and agility, and even flexibility (Philippaerts et al., 2006). For this reason, most sport specialities use annual-age grouping as an organizational strategy for youth competitions to reduce the effect of player's age on competitive outcomes (Cobley, Baker, Wattie, & McKenna, 2009). However, this strategy promotes considerable bias in the selection process and in the participation of young athletes from several sport disciplines because the proportion of athletes born early in the year of selection (natural year or season year) is higher than that of the athletes born at the end of the year when compared to the normalised distribution of live births (Wattie et al., 2015). This phenomenon, known as relative age effect, has had a marked influence in soccer, because the bias of selecting players born early in the year has been shown to be evident in professional (Ostapczuk & Musch, 2013; Salinero, Pérez, Burillo, & Lesma,

2013) and young soccer players (Gutierrez Diaz Del Campo et al., 2010). Interestingly, the relative age effect is not exclusive of the selection process in soccer, as other sport disciplines such as rugby (Till et al., 2010), basketball (Delorme & Raspaud, 2009) and hockey (Sherar, Baxter-Jones, Faulkner, & Russell, 2007) also present an overrepresentation of players born early in the year in youth and professional categories. The current investigation presents a clear explanation of why relative age effect is present in soccer and why this bias should be eliminated; the increase in body height, maximal running speed, running speed with the ball and jump height was 9.3 cm, 1.0 km/h, 0.1 km/h and 2.9 cm, respectively, from 13 to 14 years of age and 8.8 cm, 1.0 km/h, 0.5 km/h and 2.5 cm, respectively from 14 to 15 years of age. This means that selecting a soccer player born early in the year might benefit the team because this player will be taller and faster than a counterpart born at the end of the year, as previously described in soccer (Carling, le Gall, Reilly, & Williams, 2009; Hirose, 2009) and other team sports (Sherar et al., 2007). However, this investigation also indicates that, although this type of selection might be beneficial for the soccer performance of the youngest categories, the discarding of late-born soccer players has no physical benefits when players are older than 17 years of age, when the relative age effect in anthropometric and physical variables tended to be trivial (see Figure 1 and 2). Thus, the process of talent identification in youth soccer should change to avoid excluding soccer players born at the end of the selection year from elite youth soccer teams, once shown that the age-benefit in physical variables is eliminated when soccer players are older than 17 years of age. This investigation is unique because allows the comparison of anthropometric and physical variables for each player with the value corresponding to his exact chronological age, instead of the comparison with other soccer players born in the same year. In addition, the equations provided in Table 2 provide the expected variation in each anthropometric and physical variable per given time and thus, soccer coaches can easily relate players of different ages or compare early-born and late-born in the year soccer players.

Running speed is one of the physical variables most affected by age (Papaiakovou et al., 2009). However, in soccer, the ability to repeat sprints is even more crucial for performance and this variable changes less with increasing age (Mujika et al., 2009). Previous investigations have determined that a plateau in sprint ability might occur at 14-15 years of age (Mujika et al., 2009) coinciding with peak height and peak body mass velocity in young soccer players. After this age, improvements in sprint ability per year are reduced, as has also been shown in the current investigation. Figure 2 indicates that soccer coaches should expect to find fast changes in the ability to sprint, to jump and to run with the ball until ~17 years of age and slower changes thereafter.

A relevant question about soccer training in young populations is to determine whether there is a suitable age for training the different physical components of soccer performance. Some investigations have suggested that it might be possible to obtain greater benefits from training during growth spurts as these periods might be identified using peak height and peak body mass velocity changes as indicators (Philippaerts et al., 2006). Although several physical and technical capacities should be developed as young as possible, the capacity to sprint and jump, anaerobic capacity is likely better developed after 15 years of age (Paterson, Cunningham, & Bumstead, 1986) just after peak height velocity is attained in soccer players (Philippaerts et al., 2006). Although more information is necessary regarding experimental programmes that examine long term training adaptations with age, our opinion is that high-intensity/high volume training regimes for the enhancement of functional performance should be emphasized after 17 years of age, when the age-effects on physical performance and growth processes are coming to an end.

This investigation describes the cross-sectional evolution of anthropometry, maximal running velocity with and without a ball and jump height in young soccer players enrolled in an academy of a professional team. Our results indicate that there are large age-effects in all anthropometric and physical variables, but the trends are markedly curvilinear from 13 to 20 years of age (Table 2). While there are great changes per year of age in body height and body mass and improvements in maximal running speed and jump height until 17 years of age, the age-related variations in these variables are much lower thereafter suggesting that most of the growth effects on anthropometry and physical performance are almost finalized at this age. In any case, the physical variables can be further improved in soccer players > 17 years of age with appropriate and specific training programs.

CONCLUSION

This investigation describes the cross-sectional evolution of anthropometry, maximal running velocity with and without a ball and jump height in young soccer players enrolled in an academy of a professional team. Our results indicate that there are large age-effects in all anthropometric and physical variables, but the trends are markedly curvilinear from 13 to 20 years of age (Table 2). While there are great changes per year of age in body height and body mass and improvements in maximal running speed and jump height until 17 years of age, the age-related variations in these variables are much lower thereafter suggesting that most of the growth effects on anthropometry and physical performance are almost finalized at this age. In any case, the physical variables can be further improved in soccer players > 17 years of age with appropriate and specific training programs. This information should therefore be taken into account when comparing and interpreting anthropometry and physical testing in young soccer players. By using this analysis, it is feasible to calculate the "expected" values for a given exact age and thus, soccer coaches can easily compare soccer players with same age but born early vs late in the year. The bias of the relative age effect in the selection process of youth soccer could be reduced by using these normalized data of a high-performance academy or by establishing the last stage of the selection process in youth soccer after the 17 years of age, when most variables have reached a plateau.

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