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Peak height velocity and muscle mass in young soccer players.

Pico de crecimiento y masa muscular en jugadores jóvenes de fútbol.

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ABSTRACT

Introduction: It has been reported that peak height velocity could be an important period in body development in athletes. The objective was to examine the peak height velocity and maturity offset in young soccer players and analyze anthropometrical measures relate with body development.

Material and methods: Fifty-eight male young soccer players were studied. They were categorized in three diverse age categories, Under-19 (post-peak height velocity), Under-16 (on peak height velocity) and Under-14 (pre-peak height velocity) years old. Height, sitting height, weight, girths and skinfolds were measured to determine peak height velocity, maturity offset and body components. Descriptive statistics means (Standard Deviation) were calculated. One-way Anova analyses and Pearson correlations were determined. The level of significance was set at $p<0.05$.

Results: The mean height and weight values were 167.63 (10.52) cm and 60.12 (12.43) kg, the medium fat mass was 13.49 (3.65)%. The average muscular transverse areas for arm, thigh and calf were 41.70 (10.82) cm^2, 154.87 (38.02) cm^2 and 85.76 (17.67) cm^2 respectably. The average PHV was 13.97 (0.53) years and the median maturity offset was 1.00 (1.92) years. Significant differences were found among the three age categories analyzed for the anthropometrical elements and for the maturity offset. Significant correlations between maturity offset and anthropometrical components were obtained.

Conclusions: In agreement with previous studies, increases on anthropometrical components and muscle areas were reported after the peak velocity. Consequently, peak height velocity and maturity offset should be considered in young soccer players' management.

Keywords: Growth and Development; Adolescent; Sports; Soccer; Anthropometry.

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RESUMEN

Introducción: Se ha observado que el pico de crecimiento podría ser un período importante en el desarrollo de deportistas. Objetivo: Determinar el pico de crecimiento y el estado madurativo en jugadores jóvenes de fútbol y analizar medidas antropométricas relacionadas con el desarrollo corporal.

Material y métodos. Cincuenta y ocho jugadores se clasificaron en 3 categorías de edad diferentes, Sub-19 (post-pico de crecimiento), Sub-16 (en el pico) y Sub-14 (pre-pico). Se midieron la altura, la altura sentado, el peso, perímetros y pliegues para determinar el pico de crecimiento, el estado madurativo y los componentes corporales. Métodos estadísticos descriptivos (Desviación Estándar), análisis Anova de una vía y correlaciones de Pearson fueron calculados. El nivel de significación se fijó en $p<0,05$.

Resultados. La altura y el peso medios fueron de 167,63 (10,52) cm y 60,12 (12,43) kg, la grasa corporal media fue 13,49 (3,65)%. La masa muscular transversal del brazo, muslo y pantorrilla fueron 41,70 (10,82) cm^2, 154,87 (38,02) cm^2 and 85,76 (17,67) cm^2. El pico de crecimiento y el estado madurativo medios fueron 13,97 (0,53) y 1,00 (1,92) años. Se encontraron diferencias significativas entre las categorías analizadas para los parámetros antropométricos y el estado madurativo. Se obtuvieron correlaciones entre el estado madurativo y los componentes antropométricos.

Conclusiones. Se reportaron incrementos en componentes antropométricos y en las áreas musculares tras el pico de crecimiento. Consecuentemente, el pico de crecimiento y el estado madurativos deberían ser tenidos en cuenta en el manejo de deportistas jóvenes.

Palabras clave: Crecimiento y Desarrollo; Adolescente; Deportes; Fútbol; Antropometría.

INTRODUCTION

From long time ago, it is well known that development state could be different in teenagers in the same chronological age. Consequently maturity assessment is needed to be taken in consideration in adolescent sport stratification in order to equalize competition and in the management of body development in athletes. The peak height velocity (PHV) is a common method used to examine the maturational state in adolescent body development(1). In order to determine this PHV an equation based on gender, age and anthropometric components has been previously validated(2). Maturity offset equation was a noninvasive and reliable method to determine the biological age in teenagers. Furthermore, these equations have presented a correlation with skeletal age offset, showing a maturational commonality between these two methods. Chae et al.(3) described that the age at PHV differs in function of gender and the height velocity growth was higher in boys that in girls. Additionally, it has been mentioned(4) that men reach their PHV later than women.

A previous study(5) investigated the influence of several factors (relative age, anthropometry and fitness) in the career attainment outcomes in 580 junior league rugby players. These elements could have a real impact in the career attainment of these rugby players. Consequently, talent identification programs should pay attention to biological age. Philippaerts et al.(6) analyzed changes in PHV and physical performance in male youth soccer players. Interestingly, many physical sport performances such as balance, speed, muscular endurance, explosive strength, agility, cardiorespiratory capacity and anaerobic endurance presented a peak evolution during the peak height velocity. Perhaps, these improvements could be connected with changes in body development and composition. Additionally, Buchheit and Mendez-Villanueva(7) examined the role of maturity status in match running performance, focusing on maximal sprinting and aerobic speeds. More mature soccer players exhibited higher values on match running performance. However, another research(8) discovered that adolescent growth could affect to vulnerability for injuries in soccer players. Athletes exhibited a higher significant probability to suffer traumatic and overuse injuries during the year of PHV than the year before. Moreover, days missed as consequence of injuries, match and training injury incidences were higher during the PHV year. Maturation and growth are potentiality risk factors for injuries in youth soccer players.

Bidaurrazaga-Letona et al.(9) studied the elements involved in the identification and selection of young soccer players. Body size and maturation are important factors to pay attention. Highlighting that identification and promotion of young soccer players by coaches are based on factors which are age-dependent. Another research(10) studied maturity-specific relationships of static/dynamic balance with power and strength analyses in young male soccer players they examine athletes pre- (-3 years to > -1 years from PHV), circa PHV (-1 to +1 years from PHV) and post- (>1 to +3 years from PHV) PHV state. Relations between balance and muscle power/strength were described, these associations were increased with maturity, indicating a possible enhancement in body composition. Supplementary, another study[11] analyzed the effect of maturation in selection procedures in basketball. Basketball players reached their PHV at an earlier age than general population, suggesting a possible connection between maturity timing and selection procedures in basketball. Therefore, it seems that PHV could play an essential role in young soccer player's selection, sport performance and injury risk.

The purposes of the present research were to examine the PHV and maturity offset in youth soccer players and analyzed relations between maturity offset values and anthropometric components.

MATERIALS AND METHODS

Subjects. Fifty eight male young soccer players voluntary participated in the current study. Eighteen players were in the Under-14 team (U-14, age 12.54 years), seventeen in Under-16 category (U-16, age 14.49 years) and twenty-three in the Under-19 category (U-19, age 17.24 years). Thus, adolescent athletes at pre-PHV, on PHV and post-PHV were included in the current study. This classification was previously used to study PHV in young soccer players(12). They had trained for ~1.5 hour/day, 4 day/week (including a weekly competitive match) during the previous year. All players were regularly involved in competitive seasons. They delivered informed written consents which had been signed by their parents.

The experimental protocol was written following the ethics rules from Helsinki Declaration. All experimental procedures were in accordance with the Pablo de Olavide University Ethical Committee rules.

Anthropometric data were collected by highly trained and experienced technicians certified by the International Society for the Advancement of Kinanthropoemtry (ISAK) level 1. Height and sitting height were measured with a stadiometer (Seca), to the nearest 0.1 cm, and an anthropometrical bench. Weight was determined using an electronic weighing machine (Tanita UM-076) to the nearest 0.1 kg. Body perimeters were also collected with a metal tape measure, narrow and inextensible (Cescorf) to the nearest 0.1 cm. Skinfolds were taken with a slim guide skinfold caliper, to the nearest 0.5 mm. The anthropometric characteristics measured were height, sitting height, weight, three girths (arm relaxed, thigh and calf) and three skin folds (triceps, thigh and calf). Leg length was calculated as height minus sitting height. Data were obtained following the standard techniques from the ISAK(13-15), given the technical error of measurement (TEM) intra-observer (7.5% to skinfolds and 1.5% to basic measurements, girths and lengths).

Experimental Approach to the Problem

The equation used was:

maturity offset = -9.236 + 0.0002708·Leg Length and Sitting Height interaction -0.001663·Age and Leg Length interaction + 0.007216·Age and Sitting Height interaction + 0.02292·Weight by Height ratio.

A previous study(2) used this equation in male teenagers obtaining R = 0.94, R^2 = 0.891 and SEE = 0.592. PHV was calculated as the result of the chronological age less the value of maturity offset. Although, anthropometric equations are commonly accepted to predict PHV in adolescents, it has been recently proposed that radiographic-based methods are more accurate and reliable[16]. Authors decided to use anthropometric equations because they did not have access to radiographic technology.

Moreover, fat mass was determined with Slaughter´s equation that considers sex, triceps skinfold and calf skinfold[17]. It has been recently validated in teenagers[18]. Muscle mass was estimated in a cross-sectional way for the arm, the thigh and the calf. Triceps, thigh and calf skinfolds, and arm relaxed, calf and thigh girths were measured to determine muscle transverse areas. This method has been previously used to evaluate muscle mass[19,20].

SigmaPlot 12.5 version (Systat software) was used for Statistical Analysis. Descriptive statics (mean [Standard Deviation]) were reported for the different parameters analyzed. Variables were normally distributed. One-way Anova analyses were used in order to determine significant differences. Correlations between different variables were examined through the Pearson correlation analysis. The level of significance was set at $p<0.05$.

RESULTS

The mean height was 167.63 (10.52) cm, the sitting height was 87.36 (6.67) cm, the global value for leg length was 80.27 (4.78). The medium weight in the sample examined was 60.12 (12.43) kg, the mean values for triceps, thigh and calf skinfolds were 9.17 (2.81) mm, 11.70 (4.30) mm and 7.83 (2.74) mm. The values for arm relaxed, thigh and calf girths were 25.57 (3.16) cm, 47.45 (5.07) cm and 35.11 (3.21) cm respectively. In table 1 can be observed these anthropometrical characteristics for the three different teams examined.

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Table 1. Anthropometrics characteristics of soccer players analyzed.

Data /Soccer category	U-14 (n=18)	U-16 (n=17)	U-19 (n=23)	P value
Height (cm)	155.02 (6.64)*	169.83 (4.89)*	175.88 (5.49)*	<0.001
Sitting height (cm)	79.28 (4.13)*	87.94 (2.13)*	93.25 (3.00)*	<0.001
Leg length (cm)	75.73 (3.29)*	81.89 (3.95)	82.62 (3.86)	<0.001
Weight (kg)	45.37 (6.02)*	60.76 (4.71)*	71.18 (7.09)*	<0.001
Triceps skinfold (mm)	9.77 (3.28)	8.26 (2.20)*	9.37 (2.76)	0.370
Thigh skinfold (mm)	14.63 (4.35)*	10.88 (3.51)	10.02 (3.70)	0.001
Calf skinfold (mm)	9.27 (3.00)*	7.60 (2.16)	6.87 (2.53)*	0.014
Arm relaxed circumference (cm)	22.09 (1.74)*	26.05 (1.93)*	27.93 (2.21)*	<0.001
Thigh circumference (cm)	42.14 (3.26)*	48.13 (3.05)*	51.10 (3.78)*	<0.001
Calf circumference (cm)	31.68 (1.86)*	35.44 (1.53)*	37.55 (2.54)*	<0.001

Note: Data is reported as mean (standard deviation); U-14, U-16; U-19: Under-14, 16, 19 category, respectively; n: sample size. *value was significant different from the rest of the groups at p<0.05.

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The mean age in the athletes analyzed was 14.97 (2.08) years, the average PHV was 13.97 (0.53) years and the median maturity offset was 1.00 (1.92) years. In Table 1 can be viewed the age, and the maturity in the three age categories analyzed.

The mean fat mass was 13.49 (3.65)%, the average muscular transverse areas for arm, thigh and calf were 41.70 (10.82) cm^2, 154.87 (38.02) cm^2 and 85.76 (17.67) cm^2 respectably. In table 2 can be observed these values in the three soccer categories examined.

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Table 2. Fat mass and muscle transverse areas of soccer players studied.

Soccer team	Fat mass (%)	Arm muscle transverse area (cm^2)	Thigh muscle transverse area (cm^2)	Calf muscle transverse area (cm^2)
U-14 (n=18)	15.00 (4.22)	28.98 (4.90)*	113.07 (21.46)*	66.16 (8.89)*
U-16 (n=17)	12.66 (2.95)	44.00 (6.03)*	159.74 (20.05)*	87.10 (8.10)*
U-19 (n=23)	12.93 (3.42)	49.96 (7.12)*	183.99 (27.64)*	100.11 (13.02)*
P value	0.143	<0.001	<0.001	<0.001

Note: Data is reported as mean (standard deviation); U-14, U-16; U-19: Under-14, 16, 19 category, respectively; n: sample size. *value was significant different from the rest of the groups at $p<0.05$.

In table 3 can be observed the correlations found between the different variables analyzed. It has been obtained significant correlations between the three muscle areas examined and the maturity offset, indicating a positive relation between them. Other correlations between maturity offset and body development points have been reported.

Table 3. Correlations determined.

Variables related	r	P value
Maturity offset (years) / thigh muscle transverse area (cm^2)	0.72	<0.001
Maturity offset (years) / arm muscle transverse area (cm^2)	0.82	<0.001
Maturity offset (years) / calf muscle transverse area (cm^2)	0.79	<0.001
Maturity offset (years) / calf skinfold (mm)	-0.39	0.001
Maturity offset (years) / arm relaxed circumference (cm)	0.79	<0.001
Maturity offset (years) / thigh circumference (cm)	0.56	<0.001
Maturity offset (years) / calf circumference (cm)	0.80	<0.001
Maturity offset (years) / height (cm)	0.89	<0.001
Maturity offset (years) / sitting height (cm)	0.94	<0.001
Maturity offset (years) / leg length (cm)	0.64	<0.001
Maturity offset (years) / weight (kg)	0.92	<0.001
Maturity offset (years) / age (years)	0.96	<0.001

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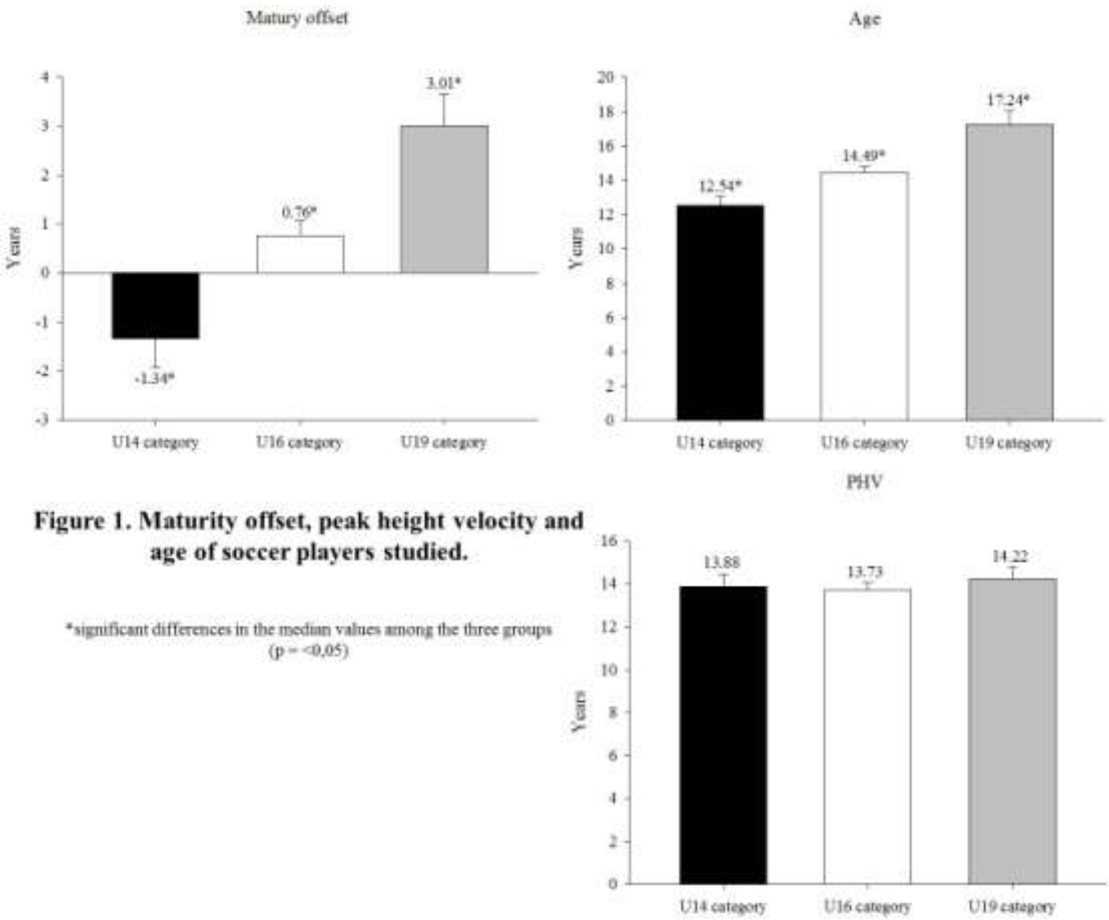
In figure 1 can be observed increases on the three muscle areas in the three groups analyzed. A non-lineal growth in muscular masses can be noticed.

Figure 1. Maturity offset, peak height velocity and age of soccer players studied.



DISCUSSION

The objective of this study was to determine maturity offset values in youth soccer and correlations between maturity offset value, anthropometrical components and muscle transverse areas. Maturity offset values differ in functions of the age category while the PHV tend to be similar in the three teams studied, indicating that one group was in a previous developmental state to the PHV, another team was immediately after the PHV and the another category had reached the PHV some time ago. In accordance with the results of a previous study[8], players from U-16 category could present a potential higher risk of suffering traumatic and overuse injuries than younger athletes because they were in the year of the PHV. Based in the results of this study, the players from this team could possibly benefit of preventive injury training.

Significant differences were observed in almost all anthropometrical elements analyzed in the three categories analyzed. In height, sitting height, leg length, weight, arm, thigh and calf girths the same tendency was found, increasing when the players were older. However, the opposite result was observed in thigh and calf skinfolds, where the younger players exhibited the highest values. Taking all these data in consideration, it seems that these anthropometrical factors could be incremented or decreased in function of having reached the PHV or not. This idea could be supported by the different correlations found between the maturity offset value and some anthropometrical components such as arm, thigh and calf girths, height, sitting height, leg length and weight. Jorquera et al.[21] observed differences in height and weight between U-16 and U-17 categories in players from several soccer teams. In affinity, another study[22] investigated anthropometry and performance in soccer players were born in the same year in order to look for differences between older and younger athletes. Older players were taller, had longer legs and presented a higher fat-free mass. The older athletes exhibited a better score performance. Figueiredo et al.[23] investigated a possible variation in size connected with changes in biological maturation in two age soccer teams. Athletes developed in maturity were heavier and taller than players retarded in maturation. Another research[24] reported that in a sample of soccer players from two age groups, the most mature athletes were the taller and heavier and also presented the longest legs length. As it was previously proposed[25] growth acceleration should be taken into account by coaches when they work with young athletes because more mature soccer players tend to present anthropometrical parameters more developed.

Interestingly, correlations between the maturity offset and the transverse muscle areas of the arm, thigh and calf have been found, indicating that a higher maturity status is possibly connected with a muscle development in the three areas analyzed. It can be noted that muscle transverse areas increase with the age of the soccer players studied. Particularly, this muscle development specially takes place after having reached the PHV, as can be visualized in the significant difference between the U-14 category and the U-16 category in the three transverse muscle areas examined. Interestingly, increases on muscle development did not follow a lineal tendency as can be observed in figure1, U-16 players were in the same year of mean PHV showed a peak in the muscle development in three muscular areas examined. Consequently, it could be speculate that PHV is a crucial period in muscle growth in soccer players. In accordance, Ahmad et al.[26] examined the effect of maturity on quadriceps-to-hamstring strength ratio. They observed that with the advanced of maturity, increases in quadriceps and hamstring muscle strength were reported in adolescents of both genders. Perhaps, these increases on muscular strength could be related with a higher muscle development in mature adolescents. Another recent study[10] determined maturity connections with strength and power measures in young soccer players. They performed strength/power measures such as back extensor muscle strength, standing long jump, countermovement jump and 3-hop jump tests. They found that post-PHV athletes exhibited better significant results in these tests. It could be possible that post-PHV who presented higher strength/power measures exhibited a greater muscle development in relation with the result obtained in the current study.

It has been showed that nutrition[27] and training programs[28] play a crucial role in skeletal muscle synthesis. We have observed a potential increase on muscle areas on PHV state, consequently, it would essential assure to fulfill nutritional requirements for soccer players on PHV period[29] in order to maximize this muscle development. Another study[30] found that arm muscle area and PHV were related with a performance parameter in rowing. Even the authors proposed that body components that influence time in rowing could be affect by maturity state in adolescent athletes. This idea would be in agreement whit the results obtained in this study. The current study constitutes one of the first studies that analyze the PHV, anthropometric parameters and muscle development in young Spanish soccer players.

Previously, it has been proposed that methods to analyze PHV, maturation or age estimation present internal limitations[31,32]. Malina et all report that the equations are really useful with teenagers close to the time of PHV, although it has limitations in early and late matured teenagers[33-35]. Their studies show that PHV could be influenced by chronological age, early and late maturation and individual differences[34,35]

In addition, a review(16) suggested that radiographic technology would be the most adequate methods to assess PHV and anthropometry methods could overestimated the timing of PHV. Nevertheless, anthropometry methods are more used by clinicians due to their open approachability and easy application. Therefore, PHV evaluation with anthropometric equations could over- or underestimate PHV timing. Consequently, PHV measurements should be contrast with radiographic methods(16).

The studies of Malina et al. conclude that equations are useful for average maturing childrens close to the time of peak height velocity, but have limitations with early and late maturing boys and girls(32-35).

The present study has limitations such as the range of sex we only examined male soccer players or that all of them played in the same soccer team. Moreover, they were not probabilistic selected. The PHV estimate through anthropometric equation-based methods presents internal limitations as an indicator of maturity timing. Radiographic technology could reduce the internal limitations to predict PHV.

The current study proposed that PHV is a notable point in young soccer player´s body development when relevant increases take part in anthropometrical components and muscle areas. Consequently, it would be valuable for physical coaches, trainers and medical services of soccer teams to consider PHV and maturity offset value when they work with young athletes Anthropometric equations are a quick, simple and accessible way to estimate PHV, although this method could present limitations.

COMPETING INTERESTS

Authors state that there are no conflicts of interest in preparing the manuscript.

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