Influence of biological maturation status on kinanthropometric and physical fitness variables in adolescent male volleyball players.

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Abstract

Backgrownd. The identification of sport talent among adolescent athletes is a topic that in recent years has been a major focus of interest for both the scientific community and sport managers. In relation to the talent identification, both kinanthropometric variables and the analysis of physical performance through fitness tests have demonstrated to be key elements, together with the assessment of maturation status, due to the influence that maturation seems to have in the mentioned variables.

Objective. To analyse differences according to biological maturation status in anthropometric characteristics and performance in physical fitness tests, as well as to determine which variables ~~could~~ predict better performance in physical fitness tests in adolescent volleyball players.

Methods. A cross-sectional design was followed to collect the data. A total of 48 male sub-elite volleyball players (14.17±0.73 years) answered a socio-demographic and sports *ad hoc* questionnaire, underwent a kinanthropometric assessment including four basic measurements, eight skinfolds, four girths (arm relaxed, flexed and tensed arm, middle thigh and calf,); five breadths (biacromial, biileocrestal, humerus, femur and bi-styloid); three lengths (acromiale-radiale, radiale-stylion and stylion-medio dactilion); and a height (ilioespinale) were measured, and physical fitness was assessed, including the sit-and-reach, back scratch, long jump, medicine ball throw, counter movement jump (CMJ), 20 meters sprint, and agility tests. Furthermore, maturity offset and age at peak height velocity (APHV) was calculated.

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Results. Significant differences were found in the basic kinanthropometric meassurements, BMI, upper limb length, corrected muscle girths, fat-related variables, muscle and bone mass (*p*<0.001-0.030), showing higher values the early maturers. In the physical fitness tests, significant differences were observed in the medicine ball throw and in CMJ power (*p*<0.001). Regression models ~~showed~~ idetified~~that~~ fat mass percentage predicted worse physical test performance (p<0.001), while age, maturation offset, muscle and bone variables were predictors of better physical performance (p<0.001).

Conclusions. Significant differences based ~~on~~ upon the stages of biological maturation were found in the anthropometric and physical condition variables in favour of the players whose maturation process was more advanced, with the variables related to fat and adipose, muscle and bone development conditioning their performance in the physical condition tests.

Introduction

The identification of sport talent among adolescent athletes is a topic that in recent years has been a major focus of interest for both the scientific community and sport managers (Hertzog et al., 2018). This interest is due to the fact that the implementation of early talent detection programmes can bring advantages to the clubs that carry them out, both in economic and sporting terms regarding the incorporation of young players into top-level teams or long-term economic security (Pion et al., 2015).

Both kinanthropometric variables and the analysis of physical performance through fitness tests have been key elements in sports talent identification programmes, as previous research has observed the influence they have on elite performance in different sport disciplines (Arede et al., 2019; López-Plaza et al., 2017b). However, it must be beared in mind that changes occur during the maturation stage that can affect both kinanthropometric and physical fitness variables, so in recent decades researchers have paid close attention to the relationship between biological maturation and these variables (Albaladejo-Saura et al., 2021).

Biological maturation has been described as the time required and the process of change until the adult stage of development is reached (Malina & Bouchard, 1991). Among the methods for monitoring biological maturation, the calculation of the age at peak height velocity (APHV) is one of the most widely used indicators (Malina & Bouchard, 1991; Mirwald et al., 2002), and more specifically, the formulas that allow the calculation of APHV based on anthropometric measurements, being a widely used and validated method that have facilitated the assessment of biological maturation in a rapid and non-invasive way (Mirwald et al., 2002).

Previous studies in adolescent boys have indicated that biological maturation seems to have a significant relationship with kinanthropometric and fitness variables, with early maturers showing higher values in kinanthropometric variables and fitness tests, probably as a result of hormonal changes that occur during biological maturation (Albaladejo-Saura et al., 2021). However, none of these studies have ~~included~~ investogated volleyball players (Albaladejo-Saura et al., 2021), although these are fundamental aspects to analyse in this sport as, due to its characteristics and rules of play, having greater agility in changes of direction, speed in sprinting

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actions and greater jumping power, being taller, having a greater arm span or leg length are differentiating elements of top level players (Zhao et al., 2019). All of these aspects could be influenced by biological maturation, being necessary to carry out studies that cover this sport modality in order to know the influence of biological maturation in these aspects with the aim of adequately orienting the programmes for the detection of sporting talent in volleyball (Albaladejo-Saura et al., 2021).

Therefore, the aim of the present research was to analyse the differences according to biological maturation in anthropometric characteristics and performance in physical fitness tests, and to determine which kinanthropometric variables could predict better performance in physical fitness tests in adolescent volleyball players.

Materials & Methods

Subjects

Sample size calculation was performed with software Rstudio (version 3.15.0, Rstudio Inc., Boston, MA, USA). Significance level was set ~~at~~ *a priori* at α=0.05. The standard deviation (SD) was set according to the years from peak height velocity from previous studies (SD=0.65) (Arede et al., 2019). With an estimated error (d) of 0.184 years from peak height velocity, the sample size needed was 48 subjects. It was conducted a non-probabilistic convenience sampling, contacting the responsible Regional Federation, which allowed us to include the best four teams in the league classification. A total of 48 1st Regional Division players (age: 14.17±0.73 years) took part in the study.

Before starting the study, coaches, parents and players were informed of the measurement procedures and signed a written informed consent form. Inclusion criteria were: a) training volleyball regularly, at least two days per week; b) participating in federated competition; c) being between 12 and 15 years old; and d) having played volleyball at least two consecutive seasons at the time of measurement. Participants were excluded in case of: a) suffering an injury that prevented them from completing the physical fitness tests; and b) having missed more than 25% of the training sessions in the last ~~3~~ three months (Albaladejo-Saura et al., 2020).

Design

A cross-sectional design was followed, in accordance with the STROBE guidelines. The San Antonio Catholic University granted Ethical approval to carry out the protocol designed for data collection in accordance with the World Medical Association Code (Code number: CE061921). The Declaration of Helsinki statements were followed during the entire process. The measurements were carried out in the players´ usual training sport hall.

Methodology

An *ad hoc* questionnaire was used to collect socio-demographic and sports information. Questions about the information needed to know if the participants met the inclusion criteria were also included.

The kinanthropometric assessment was performed following the guidelines of the International Society for the Advancement in Kinanthropometry (ISAK) (Esparza-Ros et al., 2019). Four basic measurements; eight skinfolds; four girths (arm relaxed, flexed and tensed arm, middle thigh and

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Commented [A13]: Do you mean "sample size"? if so then state that please calf,); five breadths (biacromial, biileocrestal, humerus, femur and bi-styloid); three lengths (acromiale-radiale, radiale-stylion and stylion-medio dactilion); and a height (ilioespinale) were measured. All the measurements were performed by level 2 and 3 anthropometrists accredited by ISAK. The intra- and inter-evaluator technical error of measurement (TEM) were calculated in a sub-sample. The intra-evaluator TEM was 0.04% in basic measures, lengths, heights and girths; and 1.05% in skinfolds; and the inter-evaluator TEM was 0.06% in basic measures lengths, heights and girths; and 2.87% in skinfolds.

To perform the kinanthropometric meassurements a SECA 862 scale (SECA, Alemania) with an accuracy of 100 g for measuring body mass; a SECA stadiometer (SECA, Germany) with an accuracy of 0.1 cm for measuring height and sitting height; an arm spam meter (Smartmet, Mexico) with an accuracy of 0.1 cm for measuring arm spam; a skinfold caliper (Harpenden, UK) with an accuracy of 0. 2 mm accuracy for measuring skinfolds; an inextensible tape (Lufkin, USA) with 0.1 cm accuracy for measuring girths; a segmometer (CESCORF, Brazil) with 0.1 cm accuracy for measuring heights and lengths; an anthropometer (Realmet, Spain) and a small girth sliding caliper (Holtain, UK) with 0.1 cm accuracy for measuring diameters were used.

The following measurements were calculated: Body ~~Mass~~ mass ~~Index~~ index (BMI), fat mass (Slaughter et al., 1988), muscle mass (Poortmans et al., 2005), bone mass (Matiegka, 1921), somatotype (Carter & Heath, 1990), ∑6 skinfolds (triceps, subescapular, supraespinale, abdominal, thigh and calf), ∑8 skinfolds (∑6 skinfolds + biceps and iliac crest,), cormic index [(sitting height / height) * 100], upper limb length [acromiale-radiale length + radiale-stylion length + stylion-mediodactilion length], arm corrected girth [relaxed arm girth – (π*triceps skinfold)], thigh [middle thigh girth – (π*thig skinfold)] and leg [calf girth – (π*calf skinfold)] and muscle-bone index [muscle mass / bone mass].

Maturity offset was calculated according to the procedures of Mirwald et al. (Mirwald et al., 2002), using the sex specific formula. The result was used to calculate the age at peak height velocity (APHV) for each subject using the following formula: APHV= chronological age – maturity offset result. The players were classified in three groups, according to the maturity status based on APHV, the early maturers group was composed of players whose APHV was -0.5 years or less with respect to the mean; the average maturers group, whose APHV was ±0.5 years with respect to the mean; and the late maturers group whose APHV was +0.5 years or more with respect to the mean of the group (Wickel & Eisenmann, 2007).

The physical fitness tests were selected according to previously described protocols and performed in the following order: sit-and-reach, back scratch test, long jump, medicine ball throw, counter movement jump (CMJ), 20 meters sprint, and agility test (9-3-6-3-9) (Arede et al., 2019; Castro-Piñeiro et al., 2013; Katić et al., 2006; López-Plaza et al., 2017b; Muyor et al., 2014). Before the warm-up, the subjects performed the flexibility tests (Díaz-Soler et al., 2015). This was followed by a standardised warm-up, consisting of 10 minutes of continuous running, joint mobility and familiarisation with the physical fitness tests. Two researchers with previous experience in the assessment of physical fitness tests were in charge of the familiarisation and

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assessment of these tests. The same researcher was always in charge of the same tests to avoid inter-evaluator error. The intraclass correlation coefficient (ICC) was 0.995 (95% confidence interval 0.989-0.997), and the coefficient of variation (CV) was 2.3%. The subjects made two attempts at each test, with a two-minute rest between ~~them~~tests. ~~the~~ The mean of the two trials was used as final value for subsequent analysis.

The sit-and-reach test was performed with the Acuflex Tester III (Novel Products, U.S.A); the back scratch test with a millimetre ruler (GIMA, Italy); the long jump and medicine ball throw tests with a tape measure (HaeSt, Germany) of 0.1 cm accuracy; the CMJ with a force platform (MuscleLab, Norway); the sprint test (20 m) with MySprint (Apple Inc., USA);(Romero-Franco et al., 2017) and the agility test (9-3-6-3-9) with five photocells (Microgate, Italy).

Statistical analysis

The normal distribution of the sample was assessed with the Kolmogorov-Smirnov test, as well as kurtosis, asymmetry, and homogeneity with the Levene test. A descriptive analysis of the sample was carried out. The differences between the maturation groups in the kinanthropometric variables and the physical fitness tests were analyzed using an ANOVA test, as well as the main effects and interactions of the covariable age including it in an ANCOVA test. Effect size was calculated with partial eta squared (η^2_p). Bonferroni's post hoc was used to analyse the pairwise differences between groups. The significance level was set *a priori* at $p<0.05$. The correlations between maturity offset, age, anthropometric and fitness variables were assessed using Pearson's correlation test. After that, a stepwise multiple linear regression with the variables that had shown significant correlations was performed, to find out which variables could predict performance in the physical tests. All statistical analysis was performed with SPSS ~~v.23~~ software (ver 23, IBM, Endicott, NY, US).

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Results

After calculating the APHV, the sample was divided into early (n=8), average (n=33) and late maturers (n=7). The descriptive statistics (mean±SD) of each group for all measured variables, as well as the differences between maturity groups, the main effects of the covariate age and the interaction maturity group*age can be observed in ~~table~~ Table 1.

Regarding anthropometric variables, significant differences were observed in basic measurements and BMI (F=6.003-20.828; p<0.001-0.005); in upper limb length (F=9.959; p<0.001); in all bone diameters (F=6.354-18.308; p<0. 001-0.004); in all corrected muscle perimeters (F=11.318-12.759; p<0.001); in the ∑6 and ∑8 skinfolds and fat mass in kg and percentage (F=8.876-4.368; p<0.001-0.030); and in muscle and bone masses in kg (F=18.972-19.015; p<0.001). The inclusion of the covariable "age" showed significant effect in the model in the same variables (F=4.469-88.401; p<0.001-0.040), except in the ∑6 and ∑8 skinfolds, in the fat percentage and in the bone mass (Kg). The interaction between variables showed that differences between maturity groups were influenced by age in the bone related variables (F=24.211-91.052; p<0.001), in the muscle related variables (F=5.248-22.974; p<0.001-0.027) and in the percentages of body composition (F=4.566-36.879; p<0.001-0.038).

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Pairwise comparisons after Bonferroni adjustment regarding the kinanthropometric variables can be seen in ~~tables~~ Tables 2 and 3. The early maturers group obtained higher values in the anthropometric variables than the average and late maturers (tables 2 and 3), showing significant differences in all kinanthropometric variables (p<0.001-0.030), except in the ∑6 and ∑8 skinfolds and in the fat mass percentage, where differences were found only between the early and average maturers (p=0.020-0.030). The interaction maturity group*age showed that age had a significant influence in the pairwise differences in all kinanthropométric variables (p<0.001-0.037).

In the physical fitness tests (~~table~~ Table 1), the ANOVA ~~showed~~ identified significant differences between groups in the medicine ball throw (F=10.191; p<0.001) and in CMJ power (F=16.978; p<0.001). The inclusion in the ANCOVA of the covariate age showed, in addition to the previous tests, effect in the long jump, CMJ height, sprint and agility (F=8.408-43.538; p<0.001-0.006), while the interaction maturity group*age showed significant influence of the age in the differences found between groups in the medicine ball throw, CMJ power, sprint and agility (F=10.719-103.792; p<0.001-0.008).

The significant differences found after Bonferroni adjustment in the physical tests are shown in ~~table~~ Table 4. In the medicine ball throw test and the CMJ power test, the early maturers group obtained better results than the average and late maturers groups (p<0.001-0.007); while the average group obtained better results than the late maturers group (p=0.016-0.047). The same differences between groups were found in these tests when age was included as a covariate in the model (p<0.001-0.004).

Tables 5 and 6 shows the correlations between anthropometric variables and physical performance variables. Both maturity offset and age showed moderate to high correlations with the physical fitness test (r=0.238-0.810; p<0.001-0.021). The horizontal jump test and the CMJ showed moderate positive correlations with height, sitting height, bi-styloid breath, corrected leg girth and muscle mass percentage (r=0.301-0.462; p<0.001-0.038); and moderate negative correlations with both fat mass and fat percentage (r=-0.427, -0.511; p<0.001-0.002). Medicine ball throw showed moderate to high positive correlations with all variables (r=0.330-0.829; p<0.001-0.022), except with ∑8 skinfolds, fat mass percentage and muscle mass percentage. CMJ power showed moderate to high positive correlations with all anthropometric variables analysed, except for muscle mass percentage (r=0.367-0.921; p<0.001-0.010). Sprint time showed moderate positive correlations with the fat-related variables, BMI and with the musculoskeletal index (r=0.400-0.670; p<0.001-0.005), while the correlation with muscle mass percentage was moderate negative (r=-0.459; p=0.001). The agility test showed moderate and low negative correlations with the variables height, arm spam, sitting height, upper limb length, iliospinale height, biacromial breadth and corrected leg circumference (r=-0.286, -0.488; p<0.001-0.049), while with fat mass variables the correlation was moderate positive (r=0.333-0.357; p=0.013-0.021).

Table 7 shows the linear regression models in relation to the fitness tests. Between one and three prediction models were found for the performance in the different fitness tests, which could

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explain 47 to 88% of the cases based on the kinanthropometric variables ($p<0.001$). The most determinant anthropometric variables were height, sitting height, iliospinale height, the arm and calf corrected girths, muscle mass (kg) and fat mass percentage.

Discussion

One of the objectives of the present research was to analyse the differences between maturation groups in kinanthropometric variables. In adolescent volleyball athletes. Significantly higher values were found in early maturers compared to average and late maturers in body mass, height, armspan and sitting height. These results are consistent with previous studies carried out in the adolescent male athlete population, which also found that subjects whose maturation process was more advanced showed higher values in these variables (Arede et al., 2019; López-Plaza et al., 2017b). These differences found could be related to the hormonal changes that take place around APHV (Malina & Bouchard, 1991). Previous studies have observed that both sex hormones and growth hormone (GH) increase dramatically in concentration during this stage (Handelsman et al., 2018; Malina & Bouchard, 1991). Sex hormones play an important role in the accumulation of adipose tissue and lean mass (Handelsman et al., 2018), which could explain the differences found in body mass. On the other hand, height and sitting height is markedly influenced by GH (Saenger, 2003), which could explain the higher values obtained by the subjects in the early maturers group. Similarly, the early maturers group obtained higher results in armspan and upper limb length. While in the early stages of growth, children experience cephalo-caudal and proximal-distal development (Malina & Bouchard, 1991), during adolescence growth occurs first in the limbs (Malina & Bouchard, 1991). This distal-proximal order in development could explain the differences shown between the maturation groups.

Also, significant differences were observed in adiposity-related variables (fat mass and percentage, and $\sum 6$ and $\sum 8$ skinfolds), between the early maturers and average maturers, and between early and late groups (fat mass), with higher values in the more mature subjects. These results are similar to those found in previous studies in which it was observed that in the adolescent athlete population, early maturers had a greater amount of adipose tissue (Albaladejo-Saura et al., 2021). The accumulation and distribution of adipose tissue undergoes changes during the adolescent stage in relation to sex hormones (Sandhu et al., 2005). In this case, a greater accumulation of adipose tissue seems to be related to an earlier onset of maturation in males (Sandhu et al., 2005), this could explain why, in this study, the early maturers showed a higher fat mass.

Regarding the other tissues of body composition, it was found that the group of early maturers showed significantly higher values than the average and late maturers in the components related to muscle development (muscle mass and corrected girths) and bone development (upper limb length and breadths). Previous research has shown that early maturers also have higher fat free mass and muscle mass than their peers (López-Plaza et al., 2017b). Muscle mass has been shown to be of great importance in sports performance (Fitts et al., 1991). The development of muscle mass appears to be linked to biological maturation, as the increase in muscle mass during adolescence is related to the increase in circulating testosterone, which in the male population

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Commented [A21]: Explain what you are referring to by "These differences" can be up to 30 times higher than baseline values (Handelsman et al., 2018). Bone tissue has also been shown to be of great use in sports performance, serving as a structure for muscle development (Holway & Garavaglia, 2009). Bone development occurs with a marked increase in the pubertal stage, influenced by GH, and then increases gradually into adulthood (Ohlsson et al., 1998). This increase in the hormones responsible for the increase in bone and muscle mass around APHV could be the explanation for the differences found between maturation groups in this study.

When age was introduced as a covariable, a significant influence was observed in the differences found between all groups in the basic measurements, bone variables and muscle variables, while in the fat variables only influence was observed in the differences between early and average maturers, with the early maturers group showing higher values. This phenomenon have been described in previous works analyzing the effect of age in the kinanthropometric variables. Valente dos Santos et al. (Valente-Dos-Santos et al., 2014) observed that height and fat free mass increased with age in all the maturation groups, with higher values in the more mature individuals, while the fat mass differences were smaller. In the present paper, the analyzed influence of age on the significant differences may be related to the fact that the sample of the present study had an age close to the APHV, which typically occurs in boys around 13.8±1.0 years of age (Malina & Bouchard, 1991; Rommers et al., 2019; Sherar et al., 2005), as it is in this period that the most notable changes produced by growth spurt occur, with an increase in muscle and bone tissue as age progresses (Handelsman et al., 2018; Malina & Bouchard, 1991).

Taking into account that height, arm spam and leg length are important factors in volleyball performance (Zhao et al., 2019), it could be hypothesized based on the results obtained that early maturers might have a competitive advantage in adolescent stages that could be neutralised by average and late maturers when they reach adult size. In that case, this is an issue that would need to be considered in volleyball talent identification models.

Another of the objectives of this article was to compare between groups in terms of performance in the physical fitness tests. It was shown that the early maturers performed better in the medicine ball throw and CMJ power than their peers in the average and late maturer groups, and that the average maturers performed better than the late maturers. Among the factors that positively affect the production of muscle power, it has been observed that one of the key factors is muscle mass, with a relationship existing between the increase of muscle mass and the production of power (Fitts et al., 1991). Since both tests are related to the amount of muscle mass, and in addition, the CMJ power is also related to body mass, the significant differences found in these anthropometric variables between maturation groups may help to understand why these differences were found in the physical fitness tests. On the other hand, the flexibility tests showed no significant differences between groups. This could be caused by flexibility is not a physical capacity highly influenced by the maturational process (Albaladejo-Saura et al., 2021), and yet it could be more influenced by the adaptations produced by volleyball training, as extensibility seems to be sensitive to the changes produced by training, improving it and producing morphological and neurological adaptations (Klaver et al., 2018), without the

Commented [A22]: Spelled armspan also elsewhere in the document, please be consistent influence of the maturity status on this adaptations (Albaladejo-Saura et al., 2021). The results of the present research are in line with those found in male adolescents, in which it has been found that the early maturers groups have better results than the average and late maturers in muscle strength and power-~~dependant~~dependent tests, but there were no differences in the flexibility tests between maturation groups (Albaladejo-Saura et al., 2021). In this sense, Arede et al. (Arede et al., 2019), observed that, in a sample of basketball players of a similar age to the one included in our study, the more mature players performed better in the medicine ball throw and CMJ power, but not in CMJ jump height. Similarly, López-Plaza et al. (López-Plaza et al., 2017a), observed that more mature players in a sample of kayakers performed better in the aforementioned tests than their chronological age peers.

Inclusion of the covariate age showed a significant influence on differences in medicine ball throw, CMJ power, 20 m sprint and agility tests performance. However, the pairwise analysis of the differences only showed statistical significance in the medicine ball throw and CMJ power, obtaining better results the players whose maturation process was more advanced. The influence of age has been demonstrated in previous studies, in which it has been observed that as age advances, performance in physical fitness tests improves (Rommers et al., 2019; Valente-Dos-Santos et al., 2014), especially as young athletes approach to the APHV due to the physiological and morphological changes that occur around these stages (Handelsman et al., 2018; Malina & Bouchard, 1991).

As a result of the present research, sports talent ~~detection~~ identification programmes could include assessments of these capacities, having to relativize exclusively the results of upper limbs and jumping power according to the adolescent's maturational state, as maturation does not seem to affect the other factors in isolation but rather in combination with age.

Another objective of the present research was to determine which of the variables analyzed could best predict performance in the physical fitness tests. It was found that fat mass percentage predicted worse performance in the long jump, sprint and agility tests. This may be due to the fact that in physical capacities characterized by explosive movements, added weight in the form of adipose tissue can weigh down performance by requiring greater effort for the displacements (Albaladejo-Saura et al., 2021). On the other hand, age, maturity offset and structural variables, such as height, sitting height and iliospinal height; and variables related to muscle development, such as muscle mass (kg) and corrected arm and calf circumferences, are predictors of better performance in the long jump, medicine ball throw, CMJ power and agility tests. Previous studies have already pointed out the importance of bone structure in physical performance, due to its relationship with the biomechanical parameters of strength execution and for providing the appropriate environment for better muscle development (Holway & Garavaglia, 2009). The muscle mass is a key factor to improve the performance in the physical abilities where body mass shifts in the horizontal or vertical plane, such as those that determine the volleyball performance (Sarro et al., 2019). Further research is needed to clarify if these variables related to bone and muscle mass allow the differentiation of the players according to their sport level once the adult development is reached.

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However, the present research has some limitations. Firstly, the method used to establish the maturity status of the players was not the wrist and hand x-ray, considered the gold standard (Malina & Bouchard, 1991). The equations developed by Mirwald et al. (2002), being based on regression equations, may introduce some error in the calculation of the maturity offset, limiting its use to some extent (Malina et al., 2016). Nevertheless, the reason it was used in this study was because it is a non-invasive method that is easy to apply in field research and has been widely used in recent sport science research (Albaladejo-Saura et al., 2021). Other limitations of the present study are the cross-sectional research design and the sample size. Future research could address these limitations in longitudinal research designs, with larger samples, studying the influence of biological maturation on kinanthropometric and physical fitness variables.

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Conclusions

Early maturers showed higher values in measures such as height, body mass, armspan, sitting height, bone diameters, muscle perimeters and fat, muscle and bone masses, as well as in distance achieved in the medicine ball throw and in CMJ power. These differences found in favour of players whose maturation process was more advanced could represent an advantage in volleyball sport performance during adolescence with respect to their chronological age peers. When assessing anthropometric variables and the physical condition of young players, biological maturation should be taken into account as early maturers may have a competitive advantage. Similarly, attention should be paid to variables such as height, sitting height, iliospinale height and muscle girths, as they have been shown to have a high predictive power for performance in physical fitness tests related to volleyball requirements. It should also be taken into account that when players´ age is close to APHV, the differences found between maturation groups both in kinanthropometric and physical fitness performance are influenced by age.

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