ACTA GYMNICA, 2024, Volume 54, Article e2024.003
https://doi.org/10.5507/ag.2024.003

OPEN ACCESS

ORIGINAL RESEARCH

Influence of anthropometric and fitness variables on the probability of being selected for competing in the national championship in adolescent volleyball players

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Abstract

Background: The detection of sports talent has been a recurring concern in sports science. It has been found that there is great variability in determining which athletes may perform better in sports. **Objective:** The objective of the present research was to analyse the influence of anthropometric variables, physical condition, chronological and biological age, and training variables on the possibility of being selected for the regional team competing in the national championship in adolescent volleyball players. **Methods:** A total of 100 volleyball players (48 boys, age 14.17 ± 1.00 years; 52 girls, age 14.22 ± 1.14 years) participated in the present cross-sectional design study and completed a sociodemographic and sports questionnaire. Participants underwent an anthropometric assessment, including basic measurements, skinfolds (triceps, subscapular, biceps, iliac crest, supraspinal, abdominal, thigh and calf), girths (arm relaxed, flexed and tensed arm, waist, hips, middle thigh and calf), breadths (biacromial, biiliocristal, humerus, femur, and bi-styloid), lengths (acromiale-radiale, radiale-stylion and stylion-medio-dactylion); and a height (iliospinale). After that, ∑6 and ∑8 skinfolds, body composition, upper limb length and corrected girths were calculated. Physical fitness was assessed by sit-and-reach, back scratch, long jump, medicine ball throw, countermovement jump, sprint and agility test. The maturity offset was estimated. Statistical analysis included χ^2, to analyse differences between those selected and not selected, and odd ratio (OR), to assess the possibility of being selected for competing in the national championship as a function of anthropometric, physical fitness and training variables. **Results:** It was observed that, in the group of boys, higher values in the variables related to bone mass increased the possibility of being selected (OR = 2.17–3.08). Better performance in the physical tests related to power production was a predictor of higher chances of being selected in both groups of boys and girls (OR = 0.48–2.53). In the case of the boys, a more advanced maturation process increased the possibility of being selected (OR = 0.61–1.69). Better perception of the coach in both groups and higher training volume in the case of the boys increased the chances of being selected (OR = 1.75–3.70). **Conclusions:** Better performance in the physical condition tests is an indicator of a greater probability of being selected in both boys and girls, while the anthropometric variables, a higher biological age, the volume of training and perception of the coach were the only determinants in the group of boys.

Keywords: growth, maturation, physical condition, sports performance, young athletes

Introduction

The detection of sports talent has been a recurring concern in sports science over the last few decades (Johnston et al., 2018). However, despite the numerous investigations in this regard, it has been found that there is great variability in determining what factors can differentiate those athletes who have higher sporting performance (Johnston et al., 2018). Furthermore, there is much debate as to whether this performance in the training stages is related to these athletes being more likely to perform better in adulthood and reach the elite (Dugdale et al., 2021, 2021b). Nevertheless, most studies that implement sports talent detection programs include as the main variable the physical profile of the participants, understanding by this term the anthropometric characteristics, the maturational state, the physical or physiological capacities and the performance in skills specific to the sport (Johnston et al., 2018).

More specifically, in team sports, it has been observed that adolescent players of higher sports levels have greater height and muscle mass, lower body mass and fat percentage, as well as better performance in physical condition tests related to sports performance (Arede et al., 2019; Garcia-Gil et al., 2018; Till et al., 2017). As they have a higher sports performance, previous studies have found that these athletes, who have a competitive advantage based on their physical characteristics, usually become part of specific technique and development programs (Leiva-Arcas, Vaquero-Cristóbal, Abenza-Cano, & Sánchez-Pato, 2021),

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Article history: Received May 30 2023, Accepted April 21 2024, Published May 17 2024

such as team selections to compete in the national championship. The inclusion of these athletes in high-performance programs entails a series of advantages over other athletes in their category, including access to human and material resources not available to the entire population, or the possibility of obtaining financial support to develop their sports career (Leiva-Arcas, Vaquero-Cristóbal, Sánchez-Pato, et al., 2021), which places them in a better position to become sports professionals. However, it is rarely taken into account in these types of programs or selections that most of the advantages that these players have based on their physical characteristics are the result of having an older biological or chronological age and that once the growth period is over, it is very likely that they will lose that advantage (Dugdale et al., 2021, 2021a, 2021b). Therefore, this type of model could be effective in optimizing performance in the short term, but not in the long term (Dugdale et al., 2021b).

In addition, most of the research on the characteristics that make an athlete perform better, and therefore more likely to be selected at an early age, is focused on the male population and on soccer (Albaladejo-Saura et al., 2021). This means that there is a lack of representation of the female population and less knowledge regarding the variables that could predict a greater probability of being selected for other sports (Johnston et al., 2018). The number of participants in volleyball has increased in recent years. More specifically, Spain has gone from 56,859 licences in 2010 to 95,438 in 2022 (Statistics and Studies Division, General Technical Secretariat Ministry of Culture and Sports, 2023). This fact, together with the characteristics of volleyball, which include jumps, landings and explosive actions (Tsoukos et al., 2019b), makes it relevant to know which characteristics are related to a greater probability of being selected to compete in the national championship. However, only one study has addressed this question in volleyball players in boys (Tsoukos et al., 2019b) and another in girls (Tsoukos et al., 2019a). Nonetheless, these studies did not globally address this phenomenon, including muscular and bone anthropometric variables, which are determinants of physical performance (Holway & Garavaglia, 2009), and variables related to biological maturation or relative age, which have been shown to influence anthropometric and physical condition variables (Albaladejo-Saura et al., 2021).

Therefore, the objective of this research was to analyse the influence of anthropometric variables, physical condition, chronological and biological age, and training variables on the possibility of being selected to compete in the national championship in a male and female sample of adolescent volleyball players.

Methods

Subjects

The calculation of the sample size was performed with RStudio software (Version 3.15.0; Posit Software, Boston, MA, USA). Considering that an acceptable estimated power is considered acceptable from .80 (Cohen, 1988), a calculation was made to determine the statistical power of the study, taking into account that two groups of at least 23 participants were to be compared, the expected effect size was large and the statistical significance was set at α = .05. The statistical power with these parameters was .81.

Before starting the study, the coaches, parents and players were informed about the measurement procedures and the parents signed an informed consent form. The inclusion criteria were: a) regular volleyball training, at least two days per week; b) participating in federated competitions; c) aged between 12 and 15 years old; d) having played volleyball for at least two consecutive seasons at the time of measurement. Participants were excluded if they: a) suffered an injury that prevented them from completing the tests; and b) had missed more than 25% of the training sessions in the last three months.

The institutional ethics committee of the Catholic University San Antonio of Murcia (UCAM) reviewed and authorised the protocol designed for data collection in accordance with the Code from the World Medical Association (code number CE061921). The statements of the Declaration of Helsinki were followed during the entire process.

Procedures

A descriptive cross-sectional design was followed, in accordance with the STROBE guidelines (Vandenbroucke et al., 2014).

Participants were asked to complete an ad hoc questionnaire designed to collect sociodemographic and sporting information. The questionnaire was previously explained to the participants by a researcher, and completed individually in the presence of the researcher, to resolve any doubts that might arise. The players were asked if they had been selected to compete in the national championship being part of the regional team, training days per week, training hours per week, years playing volleyball, years federated in volleyball, injuries in the previous months that kept the players out of practice, the date of birth, if they use to be starters in their team and how many sessions they missed in the last three months. The selection process consisted of two phases: in the first phase, each club in the region proposes four players of the corresponding age categories for selection, after which there is a training camp with the regional teams' coach and staff. After this first phase in which individual and collective technical-tactical criteria are evaluated, a list of 18 players is issued, which later, after a second concentration, remains at 14 players selected by category. The information on the players selected to compete in the national championship was later contrasted with data from the Volleyball Federation of Murcia, Spain. The coaches were asked to complete a questionnaire about the role and importance of each of the players in their team. They had to classify the players as "leading team players", "other important players", and "players who rarely enter the game" (Katić et al., 2006). This classification, together with the team position in the league was used to categorize the participants into more successful or less successful groups following the methods from Katić et al. (2006), this variable is categorized as "success" in the present manuscript.

An anthropometric assessment was made of the participants, according to the criteria established by the

International Society for the Advancement in Kinanthropometry (ISAK; Esparza-Ros et al., 2019). Four basic measurements; eight skinfolds (triceps, subscapular, biceps, iliac crest, supraspinal, abdominal, thigh and calf); six girths (arm relaxed, flexed and tensed arm, waist, hips, middle thigh and calf); five breadths (biacromial, biiliocristal, humerus, femur, and bi-styloid); three lengths (acromiale-radiale, radiale-stylion and stylion-medio-dactylion); and a height (iliospinale) were measured by level 2 and 3 anthropometrists accredited by the ISAK. The technical error of measurement (TEM) was calculated intra-evaluator (0.06% for basic measurements, lengths, heights and girths; 1.17% for skinfolds) and inter-evaluator (0.09% for the basic measurements, lengths, heights and girths; 2.65% for skinfolds).

A SECA 862 scale (SECA, Hamburg, Germany) with an accuracy of 100 g; a SECA 213 stadiometer (SECA, Hamburg, Germany), an arm span meter (Smartmet, Zapopan, Mexico), an inextensible measuring tape (Lufkin, Sparks, MD, USA), a segmometer (Cescorf, Porto Alegre, Brazil) an anthropometer (Realmet, Barcelona, Spain) and a small girth sliding caliper (Holtain, Crymych, United Kingdom) with a 0.1 cm accuracy; and a Harpenden skinfold caliper (Baty International, Sheffield, United Kingdom) with a 0.2 mm accuracy. All the measurements were taken twice. When the difference between the first and second measurements was greater than 5% for the skinfolds, or 1% for the other measurements, a third measurement was taken. The mean was used between measurements in the case of two attempts, and the median in the case of three measurements as the final value for the analysis.

The anthropometric measurements were used to calculate the variables of ∑6 skinfolds (triceps, subscapular, supraspinal, abdominal, thigh and calf), ∑8 skinfolds (triceps, subscapular, biceps, iliac crest, supraspinal, abdominal, thigh and calf; Esparza-Ros & Vaquero-Cristóbal, 2023); fat mass percentage (Slaughter et al., 1988), muscle mass percentage (Poortmans et al., 2005), and bone mass percentage (Matiegka, 1921) as body composition factors; and upper limb length; arm, thigh and calf corrected girths (Esparza-Ros & Vaquero-Cristóbal, 2023), as performed in previous research (Albaladejo-Saura et al., 2022b).

The maturity offset was calculated using the formulas described by Mirwald et al. (2002). The birth quartile of the participants was recorded. Considering that, due to competition regulations, each category encompasses two consecutive calendar years, the quartiles of the first year of each category were categorised with the numbers 1 to 4 respectively, and the numbers 5 to 8 were used for the quartiles of the second year of each category.

After the anthropometric assessment, a physical fitness assessment was performed, including a sit-and-reach test, back scratch test, long jump, medicine ball throw, countermovement jump (CMJ), 20-meter sprint, and an agility test (9-3-6-3-9). The order followed in the tests has also been used in previous research in similar populations (Albaladejo-Saura et al., 2022a). Flexibility tests were performed in first place, followed by a standardised warm-up consisting of 10 minutes of continuous running, followed by joint mobility and familiarization with the physical fitness tests. Two researchers with previous experience in the assessment of physical fitness tests oversaw the familiarization and assessment of these tests, with the same researcher being responsible for each test during all the measurements, in order to avoid inter-evaluator error in the assessments. Two attempts were made for each test, with a three-minute rest between them, and with the final value being the mean of the two trials.

The sit-and-reach test was performed with the Acuflex Tester III (Novel Products, Pittsburgh, PA, USA); the back scratch test with a millimetre ruler (goniometer 27340, GIMA, Gessate, Milan, Italy); the long jump and medicine ball throw tests with a measuring tape (Weiss Tape measure 50 m, HaeSt, Wolfenbüttel, Germany) with a 0.1 cm accuracy; the CMJ with the MuscleLab force platform (MuscleLab, Stathelle, Norway); the sprint test (20 m) with MySprint app (MySprint, Madrid, Spain); and the agility test (9-3-6-3-9) with five photocells (Microgate, Bolzano, Italy). All the measurements were carried out in the usual training hall.

Statistical analysis

The Kolmogorov-Smirnov and Mauchly's W tests were used to evaluate the distribution and sphericity of the sample. The descriptive statistics mean and standard deviation were calculated for the quantitative variables, and frequency and percentage were calculated for the qualitative variables. The sample was divided according to whether they had been selected to be part of the team to participate in the national championship in order to analyse the variables related to anthropometric variables, physical condition, state of maturity, birth quartile, assessment by their coaches and sporting practice that could be influencing the probability of being selected. The database was also divided by sex to see if the variables influencing males and females were similar or different. In order to perform the χ^2 and Odd Ratio tests, the continuous quantitative variables were categorised in relation to the group mean, dividing them into "greater than the mean" or "less than the mean". The Chi squared (χ^2) test was used to analyse differences between those selected and not selected on categorised discrete quantitative variables and qualitative variables. Cramer's V test (V) was used to calculate the magnitude of effect size between the two groups (selected vs. not selected). It was then classified following the procedure of previous research considering $V < .17$ a small magnitude; $V > .17$ and $V < .29$ a medium magnitude; and $V \geq .29$ a large magnitude, in line with previous research (Cobley et al., 2018). Finally, the odds ratio (OR) of being selected for competing in the national championship was calculated as a function of anthropometric, physical fitness and training variables.

The results were reported as raw odds ratios with 95% confidence intervals. The 95% confidence interval of the odds ratio was set to express the magnitude of the associations. Statistical analysis was performed using IBM SPSS Statistics (Version 24.0; IBM, Armonk, NY, USA). A value of $p < .05$ was set to determine statistical significance.

Results

A total of 100 adolescent volleyball players from the Region of Murcia took part in the study, 48 boys (age 14.17 ± 1.00 years) and 52 girls (age 14.22 ± 1.14 years), of whom 49 had been selected to compete in the national championship (23 boys, age 14.41 ± 0.85 years; 26 girls, age 14.47 ± 1.17 years).

Table 1 shows the frequency, mean and standard deviation, χ^2 and OR of the variables analysed for the sample of boys, dividing the sample into players who were selected to compete in the national championship and those who were not selected. It was shown that there were differences between selected and not selected players in the bone mass percentage and bone structure-related variables, such as height, arm span, sitting height and upper limb length (p = .001–.022), having those players who showed higher values better chances to be selected (OR = 2.17–3.08). There were also statistical differences in the mesomorphic and ectomorphic components of the somatotype (p = .009–.022), with a higher probability of being selected being observed in those players who showed a higher ectomorphy and lower mesomorphy (OR = 0.41–2.04). Regarding the biological maturation variables, differences were observed in both maturity offset and age at peak height velocity (APHV; p = .040), players who showed a more advanced maturational process were more likely to be selected (OR = 0.61–1.69). About the variables related to training, significant differences were observed between both groups in the number of Starters, years playing and years in the federation and weekly training hours (p = .001–.022), with more possibilities of being selected for those Starters, with more years playing and years in the federation and a greater number of weekly training hours (OR = 1.75–3.70). Finally, statistically significant differences were observed in the variables horizontal jump, 20m sprint and agility test (p = .009–.038), with more possibilities of being selected for the players that showed better performance in the tests (OR = 0.48–2.05). The rest of the variables analysed did not show statistical differences between groups.

Table 2 shows the frequency, mean and *SD*, χ^2 and OR of the variables analysed for the girls' sample, dividing the sample into players who were selected to compete in the national championship and those who were not selected. Statistical differences were shown in the training-related variables Starters and successful players (p = .002–.017), showing the first-choice, successful players higher chances

Table 1 Descriptive results, differences between selected and not selected players and odds ratios of being selected for national competition in relation to anthropometric and physical fitness variables in the male group

Variable	Selected (*n* = 23)	Not selected (*n* = 25)	χ^2	*p*	Cramer's *V*	Odds ratio [95% CI]
Starter	21 (91.3%)	13 (52.0%)	8.95	.003	.43	1.75 [1.18, 2.61]
Success	13 (56.5%)	8 (32.0%)	2.97	.087	.25	1.76 [0.90, 3.47]
Age (years)	14.40 ± 0.86	13.96 ± 1.11	0.75	.387	.12	1.28 [0.73, 2.27]
Body mass (kg)	62.23 ± 9.71	62.84 ± 16.03	0.38	.536	.08	1.17 [0.71, 1.93]
Height (cm)	175.31 ± 7.09	166.48 ± 9.03	11.95	.001	.49	3.08 [1.47, 6.44]
Armspan (cm)	177.56 ± 8.03	169.35 ± 10.54	6.76	.010	.37	2.17 [1.15, 4.05]
Sitting height (cm)	89.51 ± 3.75	85.83 ± 4.96	8.69	.004	.43	2.17 [1.23, 3.82]
Upper limb length (cm)	79.25 ± 3.37	75.75 ± 4.48	8.29	.004	.41	2.48 [1.25, 4.92]
Arm corrected girth (cm)	22.78 ± 2.50	23.20 ± 3.20	0.01	.971	.01	0.98 [0.52, 1.88]
Thigh corrected girth (cm)	43.92 ± 3.50	44.97 ± 5.24	0.08	.773	.04	0.92 [0.52, 1.62]
Leg corrected girth (cm)	31.64 ± 2.44	31.87 ± 2.18	0.32	.571	.08	1.18 [0.66, 2.14]
Endomorphy	2.14 ± 1.04	3.28 ± 1.91	0.77	.781	.04	0.92 [0.53, 1.60]
Mesomorphy	3.96 ± 1.04	5.14 ± 1.25	6.93	.009	.38	0.41 [0.19, 0.86]
Ectomorphy	4.50 ± 2.93	2.51 ± 1.56	5.29	.022	.33	2.04 [1.07, 3.88]
∑8 skinfolds (mm)	55.34 ± 23.06	77.05 ± 39.99	3.36	.070	.26	0.50 [0.23, 1.09]
∑6 skinfolds (mm)	69.87 ± 29.75	97.90 ± 51.72	1.68	.195	.19	0.59 [0.26, 1.34]
Fat mass (%)	14.57 ± 6.05	18.87 ± 8.20	1.44	.230	.17	0.67 [0.34, 1.31]
Muscle mass (%)	38.71 ± 2.95	38.36 ± 2.26	0.07	.790	.03	1.09 [0.59, 2.01]
Bone mass (%)	11.49 ± 1.44	10.61 ± 1.44	5.26	.022	.33	2.17 [1.07, 4.48]
Birth quartile	2.09 ± 0.23	2.23 ± 0.28	0.01	.897	.02	0.98 [0.76, 1.27]
Maturity offset (years)	0.92 ± 0.86	0.30 ± 1.16	2.97	.040	.25	1.69 [0.91, 3.13]
Age at peak height velocity (years)	13.48 ± 0.44	13.66 ± 0.66	2.97	.040	.25	0.61 [0.34, 1.10]
Years playing (years)	3.68 ± 1.69	2.54 ± 1.77	6.18	.010	.38	2.82 [1.19, 6.69]
Years federated (years)	2.90 ± 1.25	1.47 ± 1.16	14.02	.001	.54	3.70 [1.63, 8.40]
Weekly training hours (hours)	5.59 ± 1.85	5.01 ± 1.10	5.29	.022	.33	2.04 [1.07, 3.88]
Sit and Reach (cm)	3.26 ± 5.35	–1.19 ± 10.39	2.17	.141	.21	1.48 [0.87, 2.53]
Back scratch test (cm)	1.80 ± 7.32	1.42 ± 7.39	0.75	.390	.12	1.28 [0.73, 2.27]
Horizontal jump (m)	2.08 ± 0.23	1.88 ± 0.50	6.94	.009	.38	2.05 [1.15, 3.65]
Medicine ball throw (m)	6.65 ± 1.27	5.62 ± 1.40	2.97	.085	.25	1.69 [0.91, 3.13]
Countermovement jump (cm)	31.76 ± 6.14	27.51 ± 5.58	2.92	.087	.25	1.76 [0.90, 3.46]
20m sprint (s)	3.75 ± 0.25	3.91 ± 0.27	6.68	.010	.37	0.48 [0.26, 0.89]
Agility test (s)	8.75 ± 0.65	9.27 ± 0.70	4.12	.038	.30	0.51 [0.25, 1.01]

Note. Qualitative variables are expressed as frequency and percentage and the quantitative ones as mean ± standard deviation. CI = confidence interval.

of being selected (OR = 2.44–2.53). In the case of the physical performance variables, statistical differences were observed in horizontal jump and medicine ball throw (p = .002–.027), showing more possibilities of being selected for the players that showed better performance in the tests (OR = 1.89–2.51).

Discussion

One of the objectives of the present investigation was to analyse the probability of being selected to compete in the national championship according to the anthropometric characteristics of the players. When dividing the sample by sex, it was observed that boys were 2.17–3.08 times more likely to be selected if they had higher bone mass percentage, height, arm span, sitting height, upper limb length and ectomorphy values. At the same time, none of the anthropometric variables were relevant for predicting the chances of selection in the sample of girls. In the case of boys, these results are in agreement with previous research in a similar population, where it was observed that those volleyball players who were selected obtained higher values in height (Tsoukos et al., 2019b). Regarding the fact that an influence on the probability of being selected of the anthropometric variables was found in the boys' group but not in the girls' group, this could be related to the maturity status at the time of the study, since boys and girls experience different maturation rates during adolescence (Malina & Bouchard, 1991). While boys have a growth peak at around 14 years of age, with the sample included in this study being close to that age, in the case of girls this usually occurs before that age (Malina & Bouchard, 1991). In this same line, while in the case of boys, offset maturity was one of the variables that explained a greater probability of being selected (OR = 1.69), this was not so in the case of girls. In this sense, it has been observed that once the growth peak has passed during adolescence, the differences caused by the different maturation rates between individuals tend to equalise with advancing age (Dugdale et al., 2021a, 2021b), which could explain, together with the fact that the girls had passed the estimated APHV around two years earlier, why there were no differences in this group.

Another objective of this study was to analyse the probability of being selected as a function of performance in physical performance tests. When dividing the sample between sexes, similarities and differences were observed

Table 2 Descriptive results, differences between selected and not selected players and odds ratios of being selected for national competition in relation to anthropometric and physical fitness variables in the female group

Variable	Selected (n = 26)	Not selected (n = 26)	χ^2	p	Cramer's V	Odds ratio [95% CI]
Starter	22 (84.6%)	14 (53.8%)	5.78	.017	.33	2.44 [1.01,5.93]
Success	19 (73.1%)	8 (30.8%)	9.31	.002	.42	2.53 [1.31,4.95]
Age (years)	14.17 ± 1.17	13.97 ± 1.06	1.26	.262	.15	1.36 [0.80,2.33
Body mass (kg)	58.14 ± 7.49	58.03 ± 12.17	0.31	.575	.07	1.17 [0.68,2.00
Height (cm)	1.63 ± 0.06	1.61 ± 0.06	1.23	.267	.15	1.36 [0.78,2.37]
Armspan (cm)	1.64 ± 0.06	1.61 ± 0.07	1.92	.165	.19	1.48 [0.83,2.62]
Sitting height (cm)	0.85 ± 0.03	0.85 ± 0.03	1.30	.254	.16	1.40 [0.76,2.61]
Upper limb length (cm)	0.73 ± 0.03	0.71 ± 0.03	1.95	.169	.21	1.52 [0.87,2.01]
Arm corrected girth (cm)	21.19 ± 1.86	20.71 ± 2.46	1.23	.260	.15	1.36 [0.79,2.35]
Thigh corrected girth (cm)	42.32 ± 2.79	42.49 ± 5.05	0.07	.781	.04	1.08 [0.62,1.85]
Leg corrected girth (cm)	29.12 ± 1.48	29.32 ± 3.04	0.31	.580	.07	0.85 [0.49,1.48]
Endomorphy	3.71 ± 0.83	4.35 ± 1.57	0.31	.570	.08	1.16 [0.68,2.00]
Mesomorphy	3.91 ± 0.95	4.02 ± 1.18	1.23	.266	.15	0.73 [0.42,1.26]
Ectomorphy	2.48 ± 1.10	2.35 ± 1.34	0.01	> .99	.01	1.00 [0.58,1.72]
∑8 skinfolds (mm)	106.59 ± 22.23	116.88 ± 38.03	0.01	.897	.02	1.00 [0.57,1.74]
∑6 skinfolds (mm)	85.55 ± 17.10	92.69 ± 27.19	0.08	.777	.04	1.08 [0.63,1.87]
Fat mass (%)	24.83 ± 3.64	25.49 ± 4.84	0.01	.999	.01	1.00 [0.59,1.72]
Muscle mass (%)	31.47 ± 2.33	31.14 ± 2.33	0.70	.402	.11	1.27 [0.71,2.24]
Bone mass (%)	16.19 ± 1.59	15.96 ± 2.11	0.01	> .99	.01	1.01 [0.56,1.75]
Birth quartile	3.38 ± 2.00	3.92 ± 1.52	0.07	.781	.04	1.08 [0.63,1.86]
Maturity offset (years)	2.12 ± 0.84	1.77 ± 0.84	0.31	.578	.08	1.16 [0.68,2.00]
Age at peak height velocity (years)	12.35 ± 0.47	12.20 ± 0.53	1.92	.165	.19	1.48 [0.83,2.62]
Years playing (years)	5.84 ± 1.83	3.38 ± 1.41	0.07	.781	.04	1.10 [0.62,1.90]
Years federated (years)	4.15 ± 1.01	2.69 ± 1.35	1.23	.266	.15	0.72 [0.41,1.29
Weekly training hours (hours)	5.27 ± 0.75	4.90 ± 0.65	1.99	.158	.19	1.47 [0.86,2.51]
Sit and Reach (cm)	7.55 ± 7.66	6.14 ± 6.94	0.31	.575	.07	1.17 [0.66,2.06]
Back scratch test (cm)	4.02 ± 5.20	4.68 ± 5.66	0.72	.397	.12	0.79 [0.46,1.35]
Horizontal jump (m)	1.75 ± 0.12	1.62 ± 0.23	4.92	.027	.31	1.89 [1.04,3.43
Medicine ball throw (m)	5.72 ± 0.74	4.81 ± 1.03	9.32	.002	.42	2.51 [1.28,4.93]
Countermovement jump (cm)	26.41 ± 3.49	23.95 ± 4.76	2.78	.095	.23	1.59 [0.91,2.77]
20m sprint (s)	4.11 ± 0.23	4.15 ± 0.23	2.78	.095	.23	0.62 [0.34,1.12]
Agility test (s)	8.99 ± 0.69	9.28 ± 0.55	0.70	.402	.11	0.79 [0.46,1.36]

Note. Qualitative variables are expressed as frequency and percentage and the quantitative ones as mean ± standard deviation. CI = confidence interval.

between boys and girls in terms of the physical condition variables that could explain the chances of being selected, finding that better results in those tests related to the application of strength and power, were related to a higher probability of being selected, but especially in the case of the girls, upper limb power was an important factor. In the case of boys, these data are in agreement with what was observed in previous articles conducted on adolescent volleyball players (Tsoukos et al., 2019b). However, in the case of girls, there are contradictory data, because while some studies affirm that jumping ability is relevant to differentiate volleyball players of different levels (Lidor & Ziv, 2010), in other studies no relationship has been found to affirm that power production is useful to differentiate volleyball players selected to be part of a national team (Tsoukos et al., 2019a). This could be attributed to differences in the measurement protocols used to assess the variables. In the case of the review conducted by Lidor and Ziv (2010), the authors indicate that of the three articles analysed, two of them used a protocol based on jumping and marking the wall, so that the length of the arm and the height of the players could significantly influence the result. On the other hand, Tsoukos et al. (2019a), found that when analysing the reach of the spike, influenced by anthropometric variables, there were differences between those players who had been selected and those who had not, but when analysing the CMJ no differences were found, results that are in line with what was observed in the present work. Therefore, future lines of research should aim to deepen the relationships between anthropometric variables, physical condition variables and the probability of being selected in adolescent volleyball players.

Another objective of this study was to analyse the probability of being selected in relation to the chronological age, biological maturation and birth quartile of the players. When the sample was divided by sex, it was observed that more advanced biological maturation increased the chances of being selected in the group of boys. Previous studies have pointed out that different rates of biological maturation could be the basis for the differences found in anthropometric variables and physical performance in adolescent male volleyball players (Albaladejo-Saura et al., 2022a). This could be the cause of the influence of greater biological maturation on the chances of being selected in the male subgroup. In contrast, neither biological maturation nor chronological age increased the chances of being selected in the girls' group. It has been observed that the differences influenced by biological maturation are most notable around APHV and that these differences tend to attenuate as maturation progresses and subjects approach adult development (Malina & Bouchard, 1991). In the case of the players in the present study, it showed an advanced maturity offset and far from the APHV, which could be related to the absence of influence of biological maturation on the chances of being selected. However, future research should address these questions at different age ranges to further explore the relationship of age and biological maturation to the chances of being selected throughout all stages of training.

Regarding the variables related to sporting experience and training, in the group of boys, it was observed that being a starter, having more years of experience, more years in the federation and more hours of training per week could increase the probability of being selected. In the case of the group of girls, being a starter player and classified as more successful increased the chances of being selected. Previous research has found that coaches' subjective perceptions play a key role in players' physical and motor development chances (Cripps et al., 2016; Dugdale et al., 2020). In this sense, a tendency has been detected to give more development options to those players whose maturation process is more advanced and who therefore have a better performance in the sport, increasing the disadvantageous situation of the rest of the players (Cripps et al., 2016; Dugdale et al., 2020). This could encourage the chances of players who have more development opportunities at the club level to have a greater chance of being selected to compete in the national championship.

It should be noted that the present study is not without limitations. The physical fitness tests are related to volleyball performance, but they are not tests that measure direct volleyball performance. In addition, the method of estimating biological maturation has been the use of regression formulas based on anthropometry, instead of using the gold standard (X-ray methods). Some potential problems with the X-ray gold standard method have been identified and should be considered, as they are invasive, costly, and time-intensive, and moreover, they expose the participants to a significant amount of radiation (Towlson et al., 2021). Due to the potential problems of using X-ray methods, some authors have proposed using alternative less invasive methods in the adolescent population (Towlson et al., 2021). Among these, and following the results found in a recent systematic review with meta-analysis focused on young athletes, perhaps the most popularly used formula has been the one proposed by Mirwald (Albaladejo-Saura et al., 2021). On the other hand, this is a cross-sectional design, which makes it possible to analyse the relationship of the variables measured with the players' chances of being selected at a specific time, when there is no guarantee that the athletes who excel during the adolescent stage will be the ones who become part of the elite as adults (Dugdale et al., 2021, 2021b).

All these limitations mean that the results of the present study can only be extrapolated to populations with similar characteristics. Future lines of research should include larger samples of both boys and girls of different age categories, including specific tests related to volleyball performance and be carried out with longitudinal designs, which allow observing, rather than estimating, biological maturation, as well as the relationships of anthropometric variables and physical performance, following up throughout the process during the stages of training until reaching the elite.

Conclusions

In adolescent volleyball players, it has been observed that those subjects who present greater biological maturation, higher values in the variables related to bone structure and percentage, and better performance in jumping, medicine ball throwing, sprinting and agility, are more likely to be selected to compete in the national championship. However, differences were found between boys and girls, observing that a better performance in the physical condition tests is an indicator of a greater possibility of being selected in both sexes, while the anthropometric variables and biological maturation were only determinants in the group of boys. The practical applications derived from the results of the present article could be related to the variables to which coaches should pay attention when selecting players for their teams.

Acknowledgments

This research was funded by a grant from the Catholic University San Antonio of Murcia (grant number: PMAFI-08/19).

Conflict of interest

The authors report no conflict of interest.

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