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Influence of Biological Maturation Status on Kinanthropometric Characteristics, Physical Fitness and Diet in Adolescent Male Handball Players

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Abstract: The aims of this research were to analyze the differences in kinanthropometric characteristics and physical performance as a function of biological maturation, as well as to analyze these differences with the inclusion of the covariates age, maturity offset and diet, and to know how the players were classified according to BMI z-score. Seventy-three handball players (mean age: 14.17 ± 0.61) underwent a kinanthropometric assessment, physical performance tests and self-completed the KIDMED questionnaire. The sample was divided into three groups based on age at peak height velocity (APHV). Significant differences were found for basic measurements, BMI, BMI z-score, Cormic Index, muscle mass, medicine ball throw and SJ jump ($p < 0.000$–0.048), with early maturers having the highest values. All covariates included had a determinant influence on the kinanthropometric characteristics ($p < 0.000$–0.014), and both age and maturity offset showed significant differences in most physical tests ($p < 0.000$–0.033), so these covariates should be considered in evaluations to predict the future performance of players. Finally, significant differences were found between the biological maturation groups in the distribution of the BMI classification, with the normal-weight grade being the predominant one.

Keywords: biological maturation; kinanthropometry; sports performance; diet; BMI; handball

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1. Introduction

Handball is a very demanding sport due to its complexity and the numerous factors involved during the game [1]. The game of handball is characterized by fast actions of high intensity, such as jumps, dribbling or throws, intercalated with moments of transition between actions that serve the players as recovery [2–4]. Being a multifactorial sport [1], there are some factors, such as the context of the players, that also have an influence [5]. The tradition of handball in Spain is increasingly established and at a very high level; in fact, the senior national teams, both men's and women's, have been present in the last ten Europeans and in the last five World Cups that have been celebrated, on several occasions making it to the final four [6]. Additionally, although all the Spanish communities have their own handball federation, one of the main regions that provide high-level teams is the Mediterranean Coast, with numerous teams in the first and second categories in both men's and women's handball [6].

In addition, physical skills such as strength, speed or endurance are constantly influenced during the game [7,8], so it is essential that players have optimal kinanthropometric characteristics to have an adequate performance [4]. In fact, it has been observed that the best teams usually enroll tall players with low body fat who have better values of maximum strength and muscle power [4], which indicates the importance of muscle mass for handball players [4]. However, researchers have not yet been able to establish a consensus to define exactly which kinanthropometric characteristics are more related or have a greater influence on the improvement of sports performance.

Previous research considers that the kinanthropometric profile can be important for the identification of future sport talents [9], while others have observed that if the maturity status of the players is not considered during the evaluation process, kinanthropometric variables may not be as relevant in identifying talents [10]. Biological maturation, which refers to the set of changes that occur from birth to adult maturational development, occurs differently in each subject and involves numerous physiological and hormonal changes [11]. In fact, in a previous meta-analysis, it was observed how the different rhythms in the maturational status, which may also be influenced by genes and socio-economic context, can influence the kinanthropometric variables and the tests that assessed the physical aptitudes of athletes in different sports disciplines, observing that those players whose maturational process was more advanced showed values in the kinanthropometric variables and in the physical condition tests that predisposed them to a better sports performance [11–13]. Therefore, special attention should be paid to the relationship between biological maturation, kinanthropometric characteristics and physical fitness [13].

Apart from biological maturation, another variable that can affect performance during the adolescent stage is chronological age [14], probably due to changes in the hormonal environment around the age of peak height velocity (APHV) [15]. These changes, considering that all team sports group categories according to chronological age nowadays, may cause a disadvantage for those players who were born in the last months of the year [16]. In handball players, no study has been found that addresses these aspects in the growth stage, making this a necessary area for future research in this population.

The nutrition of athletes is also one of the factors that influence performance and kinanthropometric characteristics [17]. In fact, having an optimal diet and providing the necessary energy and macronutrient requirements during sports practice improves the performance and recovery of athletes [18]. In addition, during biological maturation, there is an increase in the basal metabolic rate, possibly influenced by the hormonal changes involved in this process [19]. This results in the need for an adequate diet to optimize the growth and maturational process in young athletes [20]. A healthy dietary model for athletes to follow could be the Mediterranean diet (MD), which is associated with high levels of quality of life and numerous physical benefits, and it is well established in Spain, more specifically on the Mediterranean coast where there is a tradition of passing it on from generation to generation [21–23]. Despite this and knowing that nutrition also plays a key role in the maturation process of athletes [24], no study has been found that considers these variables in handball players.

Another aspect to consider is the body mass index (BMI), which is used to classify undernutrition, underweight, normal-weight, overweight and obesity in adults, while in children and adolescents, the BMI z-score according to the World Health Organization (WHO) should be used [25]. Previous research has shown how early maturers tend to have a higher BMI value than the rest [12], probably due to the increase in weight and height that occurs during biological maturation [11]. However, there is no study in handball that addresses how BMI and its ranges of overweight and obesity vary as the maturational process progresses [12].

Therefore, the aims of this research were: (a) to observe whether there are differences according to biological maturation in kinanthropometric characteristics and physical test performance; (b) to analyze the differences between biological maturation groups in relation to age, maturity offset and diet; (c) to know how players were classified according to BMI z-score by biological maturation groups.

2. Materials and Methods

2.1. Study Design

The present research was carried out by means of a descriptive-correlational cross-sectional design, in which the maturational status, kinanthropometric characteristics, performance in different physical condition tests and adherence to the Mediterranean diet (MD) of young handball players were evaluated. Sample size calculation was performed with Rstudio (version 3.15.0, Rstudio Inc., Boston, MA, USA) software. The significance level was set a priori at $\alpha = 0.05$. The standard deviation (SD) was set according to the years of muscle mass from previous studies in adolescent athletes (SD = 2.59) [26]. With an estimated error (d) of 0.59 kg, the sample size needed was 73 subjects. The research population was chosen by means of a non-probabilistic convenience sampling among the clubs with infantile and cadet categories in the province of Alicante, located in the southeast of Spain. The province of Alicante has 49 handball teams of handball players, with 637 federative records between infants and cadets in the evaluation season. Six teams agreed to participate in the study. Even so, there are previous studies where the study population is smaller or similar [26,27].

2.2. Participants

Seventy-three young male handball players between 12 and 16 years of age voluntarily participated in this study (mean age: 14.17 ± 0.61). The criteria for inclusion in the study were: (a) be a healthy subject with medical authorization for the practice of federated sport; (b) at least two years playing handball; (c) being federated in handball; (d) training a minimum of three days per week; and (e) training for at least one month without having missed any training. The exclusion criteria for the study were: (a) being injured at the time of the evaluations; (b) having been injured one month before the evaluations.

2.3. Procedure

The research was approved by the Ethics Committee of the University of Alicante (code: UA-2022-02-01). In addition, all players were previously informed of the objectives and method of the research, and their parents or legal guardian, as well as the players, signed the informed consent before starting the research.

The evaluations were carried out during the training schedule of each team. On the evaluation days, the players were not required to have performed high-intensity exercises on the previous day nor to have performed training or stretching on the same day. First, kinanthropometric variables were measured, and the KIDMED questionnaire was completed. To continue, the participants performed the proposed physical tests.

2.4. KIDMED

Participants' adherence to the Mediterranean diet (MD) was analyzed with the KIDMED (KM) questionnaire, which assesses the quality index of MD in children and adolescents by means of 16 dichotomous questions [28]. The content of the questionnaire was explained to the participants by an expert researcher familiar with the instrument, then the participants individually self-completed.

2.5. Kinanthropometric Evaluation

Kinanthropometric measurements were taken according to the ISO 7250-1:2017 and the International Society for the Advancement of Kinanthropometry (ISAK) standard [29]. The measurements taken were as follows: four basic measurements (body mass, height, sitting height and arm span), three skinfolds (triceps, thigh and leg) and four girths (relaxed arm, flexed and contracted arm, middle-thigh and leg). A SECA 862 scale (SECA, Hamburg, Germany) with 100 g accuracy was used to measure body mass; a SECA 217 measuring stadiometer (SECA, Germany) with 1 mm accuracy was used to measure height and sitting height; an Avanutri wingspan meter (Avanutri, Três Rios, Brazil) was used to measure arm span; a CESCORF inextensible metal tape (CESCORF, Porto Alegre, Brazil) was used to measure girths; and a Slimguide caliper (Creative Health Products, Ann Arbor, MI, USA) of 0.5 mm precision. All kinanthropometric measurements were measured two or three times by an anthropometrist level 2 accredited by ISAK, depending on whether the technical error of measurement (TEM) between the first two measurements was greater than 5% in skinfolds and 1% for the rest of the measurements, taking the mean or median, respectively, for subsequent analysis. The intraevaluator TEM was 0.03% for the basic measurements, 2.24% for the skinfolds and 0.36% for the girths, and its correlation coefficient with an expert anthropometrist level 4 was 0.99 for the basic measurements, 0.91 for the skinfolds and 0.99 for the girths. The temperature of the room where the measurements were taken was standardized at 24 °C, and all measurements were taken from 15:00 to 21:00.

With the final values of the kinanthropometric measurements: to know the relationship between body mass and height, the BMI values were calculated (BMI = body mass/height^2) [30]; to know the amount of subcutaneous fat, the ∑3 skinfolds were calculated (∑3 skinfolds = triceps skinfold + thigh skinfold + leg skinfold); to know muscle areas and muscle development, the sum of ∑3 corrected girths were calculated (∑3 corrected girths = corrected relaxed arm girth + corrected thigh girth + corrected leg girth) with the formula: corrected girth = girth – $\pi \times$ skinfold [30]; to know the relationship between height and sitting height, the Cormic Index were calculated (Cormic Index = sitting height/height) $\times$ 100); to know the relationship between arm span and height, the relative arm span were calculated (relative arm span = arm span/height) $\times$ 100); and to know the distribution of body composition, the percentage of fat mass (%FM = 0.735*(triceps skinfold + leg skinfold) + 1) [31] and muscle mass (%MM = height*((0.0064*corrected relaxed arm girth^2) + (0.0032*corrected thigh girth^2) + (0.0015*corrected leg girth^2)) + (2.56*sex) + (0.136*age)) [32] were estimated, choosing these formulas because they were validated in a growing population [30].

In addition, being an adolescent population, the BMI z-score was also calculated using the WHO Anthroplus software [33]. From these values, the players were classified following WHO criteria into the following categories: undernutrition (ZS ≤ -2), underweight (ZS ≤ -1), normal-weight (ZS = -1 and 1), overweight (ZS $\geq$ 1) and obesity (ZS $\geq$ 2).

2.6. Biological Maturation

For the estimation of biological maturation, it was considered the maturity offset, which was calculated using Mirwald's formula [34]. This formula has been previously used in adolescent athletes, obtaining a high interclass correlation coefficient (ICC = 0.96), a low standard error (TE = 0.1) and a low percentage variance coefficient (CV% = 0.8) [35]. With the result obtained, the APHV was estimated for each subject, using the formula: APHV = chronological age − maturity compensation score. Following the methodology of previous articles [26], players were classified into three groups according to APHV: early maturers, those players whose APHV was −0.5 years or less with respect to the group mean; average maturers, those players whose APHV was ±0.5 years with respect to the group mean; and late maturers, those whose APHV was +0.5 years or more with respect to the group mean.

2.7. Physical Condition

The upper limb power of the players was assessed using the overhead medicine-ball-throwing test with tape measure (Haest, Wolfenbüttel, Germany) of 0.1cm precision [4].

Lower limb power was assessed using the Squat Jump (SJ) and Counter Movement Jump (CMJ). The latest version of the MyJump application [36] was used to measure the jumps and was followed the protocol previously described by Hermassi et al. [37].

Speed was measured with a 30 m sprint at the maximum possible intensity. The start and end of the test were determined by two photocells (Witty, Microgate, Bolzano, Italy).

The agility of the players was evaluated using the T-Half Test following the protocol described by Sassi et al. [38]. This test was chosen because, unlike the *t*-Test, it is shorter in distance and more representative of the game of handball. The start and end of the test were determined by means of a photocell (Witty, Microgate, Bolzano, Italy).

Endurance was assessed with the Yo-Yo Intermittent Recovery level 1 test [39]. In addition, with this test, the theoretical VO^2 max was also estimated using the formula described by Bangsbo et al. [40].

The tests were performed in the following order: medicine ball throw, SJ, CMJ, sprint, T-Half Test and the Yo-Yo test. This order was chosen following the recommendations of the National Strength and Conditioning Association (NSCA), which are based on the metabolic routes required and the fatigue generated by each physical test, leaving a rest between attempts of each test of five minutes so that fatigue interference would have the least possible effect [41]. In addition, this order has also been used in previous research with similar populations [26,42].

All players performed two valid attempts for the medicine-ball-throwing, jumping, sprinting and agility tests and a single attempt for the endurance test. In addition, the week before the measurements, a familiarization session with the protocols of each physical test was carried out. On the other hand, before each session of the physical tests, a standardized warm-up was also performed, consisting of 10 min of continuous jogging, dynamic joint mobility exercises and exercises that simulated the tests that they were going to perform in that session at low intensity. The researchers encouraged the players to perform all attempts of the physical tests at the maximum possible intensity.

2.8. Statistical Analysis

All the variables were analyzed using descriptive statistics, obtaining the mean and standard deviation. In addition, the Kolgomorov–Smirnov normality test was performed to verify that all variables had a normal distribution, kurtosis and Mauchly's sphericity test to evaluate the sphericity hypothesis. As the data had a normal distribution and with the aim of analyzing the differences according to the maturational status of the players in the kinanthropometric and derived variables and physical condition test, an analysis of variance (ANOVA) was performed. Subsequently, several ANCOVA tests were performed to observe the influences of the covariates age, maturity offset and KM score on the relationship between maturational groups, kinanthropometric and derived variables and physical condition test. For those variables in which significant differences were found, a pairwise comparison was performed using the Bonferroni correction for multiple comparisons. In addition, a chi-square test (X^2) was also performed to analyze the distribution of BMI classification according to biological maturation groups. The minimum level of statistical significance was set at $p < 0.05$. All data were analyzed using the Statistical Package for the Social Sciences (SPSS) version 25.0 (IBM, Armonk, NY, USA).

3. Results

When players were distributed according to maturational status, 20 were found to be early maturers (mean age: 14.09 ± 0.87), 40 average maturers (mean age: 13.92 ± 1.16) and 13 late maturers (mean age: 14.43 ± 0.75). Descriptive data (mean ± SD) of all variables analyzed for each group, as well as ANOVA analysis and ANCOVA analyses, including age, maturity offset and KIDMED questionnaire score as covariates, are shown in Table 1. Regarding differences between biological maturation groups for kinanthropometric characteristics, significant differences were found in basic measurements (F = 7.500–28.348; $p < 0.000$–0.001); BMI, BMI z-score and Cormic Index (F = 5.994–9.569; $p < 0.000$–0.004); and muscle mass (F = 11.206; $p < 0.000$). Regarding the results of the physical tests, significant differences were found in the medicine ball throw and in the SJ jump (F = 3.172–7.522; $p < 0.001$–0.048). In all variables with significant differences, the values of early maturers were higher compared to the rest of the groups.

Table 1. Descriptive data and differences according to biological maturation group, including the effects of the covariates age, maturity offset and KM score.

Variable	Groups Biological Maturation (Mean ± SD)			Models											
				Biological Maturation			BM*Age			BM*Maturity Offset			BM*KM		
	Early (n = 20)	Average (n = 40)	Late (n = 13)	F	*p*	η2p	F	*p*	η2p	F	*p*	η2p	F	*p*	η2p
Age (years)	14.09 ± 0.87	13.92 ± 1.16	14.43 ± 0.75	1.221	0.301	0.034	-	-	-	81.104	0.000	0.779	3.563	0.018	0.134
Maturity Offset (years)	0.62 ± 0.86	−0.33 ± 1.14	−0.71 ± 0.66	8.712	0.000	0.199	470.304	0.000	0.953	-	-	-	9.730	0.000	0.297
APHV (years)	13.46 ± 0.20	14.26 ± 0.26	15.14 ± 0.26	180.771	0.000	0.838	128.163	0.000	0.848	13.735	0.000	0.374	83.318	0.000	0.784
KM	6.25 ± 2.20	6.98 ± 2.30	6.62 ± 2.10	0.712	0.494	0.020	2.615	0.058	0.102	3.770	0.014	0.141	-	-	-
Body mass (kg)	67.59 ± 2.08	57.03 ± 11.73	48.03 ± 7.77	12.475	0.000	0.263	18.769	0.000	0.449	23.296	0.000	0.503	11.670	0.000	0.337
Height (m)	1.76 ± 0.04	1.65 ± 0.09	1.63 ± 0.09	14.712	0.000	0.296	43.231	0.000	0.653	42.338	0.000	0.648	12.114	0.000	0.345
BMI (kg/m^2)	21.85 ± 3.25	20.83 ± 3.60	17.96 ± 1.19	5.994	0.004	0.146	5.029	0.003	0.179	6.497	0.001	0.220	6.021	0.001	0.207
BMI z-score	0.88 ± 0.90	0.49 ± 1.17	−0.67 ± 0.54	9.569	0.000	0.215	6.466	0.001	0.219	4.087	0.010	0.151	7.338	0.000	0.242
Sitting height (cm)	87.25 ± 2.93	80.82 ± 4.72	77.22 ± 2.63	28.348	0.000	0.447	217.741	0.000	0.904	212.054	0.000	0.902	22.400	0.000	0.493
Arm span (cm)	177.21 ± 6.04	168.37 ± 9.46	166.97 ± 11.63	7.500	0.001	0.176	25.638	0.000	0.527	31.845	0.000	0.581	6.677	0.001	0.207
Relative arm span (%)	100.94 ± 2.45	101.98 ± 1.77	102.37 ± 2.57	2.241	0.114	0.060	1.591	0.200	0.065	0.699	0.556	0.029	1.141	0.339	0.047
Cormic Index	49.72 ± 1.96	48.96 ± 1.62	47.45 ± 2.01	6.383	0.003	0.154	6.779	0.000	0.228	7.405	0.000	0.244	3.825	0.014	0.143
Fat mass (%)	17.08 ± 7.53	19.04 ± 10.59	12.63 ± 4.09	2.507	0.089	0.067	3.492	0.020	0.132	3.178	0.029	0.121	1.862	0.144	0.075
Muscle mass (kg)	28.95 ± 5.65	24.20 ± 5.05	20.96 ± 3.06	11.206	0.000	0.243	18.589	0.000	0.447	23.758	0.000	0.508	10.462	0.000	0.313
MB throw (m)	6.40 ± 0.94	5.41 ± 1.38	4.80 ± 1.07	7.522	0.001	0.177	34.957	0.000	0.603	44.893	0.000	0.661	6.895	0.000	0.231
T-Half Test (s)	6.69 ± 0.69	6.87 ± 0.72	6.48 ± 0.78	1.487	0.233	0.041	3.128	0.031	0.120	1.756	0.164	0.071	1.202	0.316	0.050
SJ (cm)	25.69 ± 5.50	21.92 ± 5.77	23.16 ± 4.26	3.172	0.048	0.083	10.239	0.000	0.308	10.338	0.000	0.310	3.297	0.025	0.125
CMJ (cm)	28.44 ± 6.42	25.22 ± 7.31	28.40 ± 4.98	2.052	0.136	0.055	14.055	0.000	0.379	11.244	0.000	0.328	3.134	0.031	0.120
Sprint (s)	4.34 ± 0.38	4.55 ± 0.39	4.49 ± 0.37	2.052	0.136	0.055	8.737	0.000	0.275	7.047	0.000	0.235	1.796	0.156	0.072
YoYo distance (m)	1102 ± 432	933 ± 415	963 ± 436	1.083	0.344	0.030	3.072	0.033	0.118	3.380	0.023	0.128	1.554	0.208	0.063
YoYo VO^2 max *	45.66 ± 3.63	44.24 ± 3.48	44.49 ± 3.66	1.083	0.344	0.030	3.072	0.033	0.118	3.380	0.023	0.128	1.554	0.208	0.063

SD: standard deviation; BM: biological maturation; KM: KIDMED; APHV: the age of peak height velocity; BMI: body mass index; MB: medicine ball; SJ: squat jump; CMJ: counter movement jump; *: (mL/min/kg).

Inclusion of the covariates age, maturity offset and KIDMED score showed significant differences in the same kinanthropometric variables (F = 3.825–217.741; $p < 0.000$–0.014). In addition, the covariates age and maturity offset also showed significant differences for MG (F = 3.178–3.492; $p < 0.005$–0.029). Regarding the physical test results, the inclusion of the covariate age showed significant differences in all of them (F = 3.072–34.957; $p < 0.000$–0.033); the inclusion of the covariate maturity offset showed significant changes in all physical test results (F = 3. 380–44.893; $p < 0.000$–0.023), except for the T-half test (F = 1.756; $p = 0.164$); and the inclusion of the KM score covariate also showed significant changes in the medicine ball throw and SJ and CMJ jumps (F = 3.134–6.895; $p < 0.000$–0.031).

Table 2 shows the Bonferroni adjustment for those variables for which significant differences were found after ANOVA analysis, the kinanthropometric characteristics and the results of the physical tests. When the groups compared were early maturers with late maturers, significant differences were found in all variables, both kinanthropometric characteristics and physical test results ($p < 0.000$–0.007), except for the SJ jump ($p = 0.595$). When comparing early to average maturer groups, significant differences were found in most variables ($p < 0.000$–0.042), except for BMI, BMI z-score and formic index ($p = 0.746$, 0.512 and 0.376, respectively). When comparing average and late maturers, significant differences were found in body mass, BMI, BMI z-score, sitting height and Cormic Index ($p < 0.002$–0.044), except for height, arm span, muscle mass, medicine ball throw and SJ jump ($p = 0.132$–1.000).

Table 2. Post hoc comparison between biological maturation groups after ANOVA analysis for kinanthropometric characteristics and physical test results.

Variable	Group Comparison	Model		
		Biological Maturation		
		Mean Difference ± SD	*p*	95% CI
Maturity Offset	Early—-Average	0.96 ± 0.27	0.002	0.29 to 1.63
	Early—-Late	1.33 ± 0.36	0.001	0.46 to 2.21
	Average—-Late	0.38 ± 0.32	0.720	−0.40 to 1.16
APHV	Early—-Average	−0.79 ± 0.07	0.000	−0.96 to −0.62
	Early—-Late	−1.68 ± 0.09	0.000	−1.90 to −1.46
	Average–Late	−0.89 ± 0.08	0.000	−1.08 to −0.69
Body mass	Early–Average	10.55 ± 3.08	0.003	2.99 to 18.11
	Early–Late	19.55 ± 4.01	0.000	9.72 to 29.39
	Average–Late	9.00 ± 3.59	0.044	0.19 to 17.81
Height	Early–Average	0.10 ± 0.02	0.000	0.05 to 0.16
	Early–Late	0.13 ± 0.03	0.000	0.06 to 0.19
	Average–Late	0.02 ± 0.02	1.000	−0.04 to 0.08
BMI	Early–Average	1.02 ± 0.88	0.746	−1.14 to 3.18
	Early–Late	3.89 ± 1.15	0.003	1.08 to 6.70
	Average–Late	2.87 ± 1.03	0.020	0.35 to 5.39
BMI z-score	Early–Average	0.39 ± 0.28	0.512	−0.29 to 1.07
	Early–Late	1.55 ± 0.36	0.000	0.66 to 2.44
	Average–Late	1.17 ± 0.33	0.002	0.37 to 1.96
Sitting height	Early–Average	6. 44 ± 1.09	0.000	3.75 to 9.12
	Early–Late	10.03 ± 1.42	0.000	6.54 to 13.52
	Average–Late	3.59 ± 1.27	0.019	0.47 to 6.72
Arm span	Early–Average	8.84 ± 2.49	0.002	2.72 to 14.96
	Early–Late	10.25 ± 3.25	0.007	2.28 to 18.21
	Average–Late	1.40 ± 2.91	1.000	−5.73 to 8.54
Cormic Index	Early–Average	0.76 ± 0.49	0.376	−0.44 to 1.96
	Early–Late	2.27 ± 0.64	0.002	0.71 to 3.83
	Average–Late	1.51 ± 0.57	0.031	0.11 to 2.91
Muscle mass	Early–Average	4.74 ± 1.35	0.002	1.42 to 8.07
	Early–Late	7.98 ± 1.76	0.000	3.66 to 12.31
	Average–Late	3.24 ± 1.58	0.132	−0.63 to 7.11
MB throw	Early–Average	0.99 ± 0.33	0.013	0.16 to 1.81
	Early–Late	1.60 ± 0.44	0.001	0.53 to 2.67
	Average–Late	0.61 ± 0.39	0.359	−0.34 to 1.57
SJ	Early–Average	3.77 ± 1.50	0.042	0.09 to 7.44
	Early–Late	2.53 ± 1.95	0.595	−2.25 to 7.30
	Average–Late	−1.24 ± 1.74	1.000	−5.52 to 3.04

SD: standard deviation; CI: confidence interval; APHV: the age of peak height velocity; BMI: body mass index; MB: medicine ball.

Tables 3 and 4 also show the Bonferroni adjustment for those variables for which significant differences were found after ANCOVA analysis according to age, maturity offset, APHV and KM for kinanthropometric characteristics and physical test results, respectively.

With the inclusion of the covariate age, significant differences were found in the variables of body mass, height, sitting height, muscle mass and medicine ball throw in all comparisons between all groups ($p < 0.000$–0.024). For BMI, BMI z-score and Cormic Index, significant differences were found when comparing the late maturer group with the early and average maturer groups ($p < 0.000$–0.010). On the other hand, for the arm span variable, significant changes were observed when comparing the early maturing group with the rest ($p < 0.000$–0.001).

With the inclusion of the maturity offset covariate, significant differences were only found in BMI z-score and sitting height when comparing the average maturer and late maturer groups ($p < 0.021$ and 0.006, respectively) and in arm span when comparing early and late maturers ($p < 0.038$). For the rest of the kinanthropometric characteristics and physical test results, no significant difference was found (p = 0.084–1.000).

With the inclusion of the covariate KIDMED score, significant differences were found in all comparisons between all groups for the variables of body mass and sitting height (p < 0.000–0.029). For the variables of height, arm span, MM and medicine ball throw, significant differences were found when comparing the group of early maturers with the rest (p < 0.000–0.006). On the other hand, for the variables BMI and BMI z-score, significant differences were found when comparing the group of late maturers with the rest (p < 0.001–0.020). Finally, for the Cormic Index and SJ jump, significant differences were only found when comparing the early maturers with late ($p < 0.009$) and early with average ($p < 0.022$) groups, respectively.

Table 3. Post hoc comparison between biological maturation groups after ANOVA analysis as a function of the covariates age, maturity offset and KM score, for kinanthropometric characteristics.

Variable	Group Comparison	Model								
		BM*Age			BM*Maturity Offset			BM*KM		
		Mean Difference ± SD	*p*	95% CI	Mean Difference ± SD	*p*	95% CI	Mean Difference ± SD	*p*	95% CI
Age	E–A	-	-	-	0.05 ± 0.02	0.020	0.01 to 0.10	0.19 ± 0.26	1.000	−0.48 to 0.84
	E–L	-	-	-	−0.04 ± 0.03	0.336	−0.11 to 0.02	−0.37 ± 0.34	0.857	−1.22 to 0.47
	A–L	-	-	-	−0.10 ± 0.02	0.000	−0.15 to −0.04	−0.56 ± 0.30	0.190	−1.30 to 0.17
Maturity Offset	E–A	0.80 ± 0.07	0.000	0.63 to 0.96	-	-	-	0.91 ± 0.26	0.002	0.28 to 1.54
	E–L	1.63 ± 0.08	0.000	1.42 to 1.84	-	-	-	1.23 ± 0.33	0.001	0.41 to 2.04
	A–L	0.84 ± 0.08	0.000	0.65 to 1.03	-	-	-	0.31 ± 0.29	0.841	−0.39 to 1.02
APHV	E–A	−0.80 ± 0.07	0.000	−0.96 to −0.63	0.05 ± 0.02	0.020	0.01 to 0.10	−0.72 ± 0.08	0.000	−0.91 to −0.52
	E–L	−1.63 ± 0.09	0.000	−1.84 to −1.42	−0.04 ± 0.03	0.336	−0.11 to 0.02	−1.60 ± 0.10	0.000	−1.85 to −1.35
	A–L	−0.84 ± 0.08	0.000	−1.03 to −0.65	−0.10 ± 0.02	0.000	−0.15 to−0.04	−0.88 ± 0.09	0.000	−1.10 to −0.66
KM	E–A	-	-	-	−0.07 ± 0.08	1.000	−0.27 to 0.13	-	-	-
	E–L	-	-	-	0.01 ± 0.12	1.000	−0.28 to 0.30	-	-	-
	A–L	-	-	-	0.09 ± 0.10	1.000	−0.15 to 0.32	-	-	-
Body mass	E–A	9.68 ± 2.68	0.002	3.10 to 16.27	−0.54 ± 0.36	0.399	−1.41 to 0.33	8.91 ± 2.92	0.010	1.74 to 16.07
	E–L	21.05 ± 3.45	0.000	12.60 to 29.51	0.39 ± 0.52	1.000	−0.89 to 1.67	17.66 ± 3.79	0.000	8.36 to 26.96
	A–L	11.40 ± 3.11	0.001	3.74 to 18.99	0.93 ± 0.42	0.096	−0.11 to 1.97	8.75 ± 3.29	0.029	0.67 to 16.84
Height	E–A	0.09 ± 0.01	0.000	0.05 to 0.13	0.00 ± 0.00	0.360	−0.00 to 0.01	0.10 ± 0.02	0.000	0.05 to 0.15
	E–L	0.14 ± 0.02	0.000	0.09 to 0.19	0.01 ± 0.00	0.130	−0.00 to 0.01	0.13 ± 0.03	0.000	0.06 to 0.19
	A–L	0.05 ± 0.02	0.024	0.00 to 0.09	0.00 ± 0.00	0.684	−0.00 to 0.01	0.02 ± 0.02	0.915	−0.03 to 0.08
BMI	E–A	1.00 ± 0.87	0.763	−1.13 to 3.14	−0.22 ± 0.12	0.215	−0.51 to 0.07	0.61 ± 0.85	1.000	−1.47 to 2.69
	E–L	4.06 ± 1.12	0.002	1.31 to 6.80	0.07 ± 0.17	1.000	−0.36 to 0.50	3.29 ± 1.10	0.011	0.59 to 5.99
	A–L	3.05 ± 1.01	0.010	0.58 to 5.53	0.29 ± 0.14	0.138	−0.06 to 0.63	2.68 ± 0.96	0.020	0.34 to 5.03
BMI z-score	E–A	0.41 ± 0.28	0.444	−0.28 to 1.10	−0.06 ± 0.04	0.403	−0.16 to 0.04	0.23 ± 0.27	1.000	−0.44 to 0.91
	E–L	1.50 ± 0.36	0.000	0.61 to 2.38	0.07 ± 0.06	0.674	−0.07 to 0.22	1.38 ± 0.36	0.001	0.50 to 2.25
	A–L	1.09 ± 0.32	0.004	0.29 to 1.88	0.13 ± 0.05	0.021	0.02 to 0.25	1.14 ± 0.31	0.001	0.38 to 1.90
Sitting height	E–A	5.78 ± 0.46	0.000	4.66 to 6.91	−0.09 ± 0.06	0.565	−0.24 to 0.07	6.13 ± 1.05	0.000	3.57 to 8.70
	E–L	11.06 ± 0.59	0.000	9.61 to 12.50	0.16 ± 0.09	0.276	−0.07 to 0.40	9.47 ± 1.36	0.000	6.14 to 12.81
	A–L	5.28 ± 0.53	0.000	3.97 to 6.58	0.25 ± 0.08	0.006	0.06 to 0.44	3.34 ± 1.18	0.018	0.44 to 6.24
Arm span	E–A	7.54 ± 1.91	0.001	2.87 to 12.22	0.50 ± 0.25	0.150	−0.14 to 1.11	8.81 ± 2.42	0.002	2.88 to 14.74
	E–L	11.69 ± 2.45	0.000	5.68 to 17.69	0.94 ± 0.37	0.038	0.04 to 1.85	10.93 ± 3.14	0.003	3.30 to 18.62
	A–L	4.14 ± 2.21	0.194	−1.27 to 9.56	0.44 ± 0.30	0.427	−0.29 to 1.18	2.11 ± 2.73	1.000	−4.58 to 8.80
Cormic Index	E–A	0.74 ± 0.47	0.371	−0.42 to 1.90	−0.15 ± 0.06	0.084	−0.31 to 0.01	0.66 ± 0.49	0.548	−0.55 to 1.87
	E–L	2.47 ± 0.61	0.000	0.98 to 3.95	−0.08 ± 0.10	1.000	−0.31 to 0.16	1.97 ± 0.64	0.009	0.40 to 3.54
	A–L	1.73 ± 0.55	0.007	0.39 to 3.07	0.07 ± 0.08	1.000	−0.12 to 0.26	1.30 ± 0.56	0.066	−0.07 to 2.67
Fat mass	E–A	−1.28 ± 2.39	1.000	−7.16 to 4.59	−0.66 ± 0.34	0.164	−1.48 to 0.18	-	-	-
	E–L	3.60 ± 3.07	0.738	−3.94 to 11.14	0.23 ± 0.49	1.000	−0.98 to 1.45	-	-	-
	A–L	4.88 ± 2.77	0.248	−1.92 to 11.68	0.89 ± 0.40	0.089	−0.09 to 1.87	-	-	-
Muscle mass	E–A	4.41 ± 1.17	0.001	1.54 to 7.27	−0.34 ± 0.15	0.093	−0.71 to 0.04	4.15 ± 1.29	0.006	0.99 to 7.31
	E–L	8.74 ± 1.50	0.000	5.07 to 12.42	−0.04 ± 0.23	1.000	−0.60 to 0.509	7.42 ± 1.67	0.000	3.32 to 11.53
	A–L	4.33 ± 1.35	0.006	1.02 to 7.65	0.29 ± 0.18	0.343	−0.16 to 0.74	3.27 ± 1.45	0.083	−0.29 to 6.84

BM: Biological Maturation; SD: Standard deviation; CI: Confidence interval; APHV: the age of peak height velocity; BMI: body mass index; E: early maturers; A: average maturers; L: late maturers.

Table 4. Post hoc comparison between biological maturation groups after ANOVA analysis, as a function of the covariates age, maturity offset and KM score, for physical test results.

Variable	Group Comparison	Model								
		BM*Age			BM*Maturity Offset			BM*KM		
		Mean Difference ± SD	*p*	95% CI	Mean Difference ± SD	*p*	95% CI	Mean Difference ± SD	*p*	95% CI
MB throw	E–A	0.82 ± 0.23	0.002	0.25 to 1.40	0.03 ± 0.03	0.866	−0.04 to 0.11	1.03 ± 0.32	0.006	0.28 to 1.82
	E–L	1.84 ± 0.30	0.000	1.10 to 2.58	0.09 ± 0.04	0.171	−0.02 to 0.19	1.60 ± 0.42	0.001	0.57 to 2.63
	A–L	1.02 ± 0.27	0.001	0.35 to 1.69	0.05 ± 0.04	0.424	−0.03 to 0.14	0.57 ± 0.36	0.372	−0.33 to 1.46
T-Half Test	E–A	−0.15 ± 0.19	1.000	−0.62 to 0.32	-	-	-	-	-	-
	E–L	0.13 ± 0.25	1.000	−0.48 to 0.73	-	-	-	-	-	-
	A–L	0.28 ± 0.22	0.651	−0.27 to 0.82	-	-	-	-	-	-
SJ	E–A	3.16 ± 1.31	0.056	−0.06 to 6.38	0.30 ± 0.18	0.315	−0.15 to 0.75	4.03 ± 1.46	0.022	0.45 to 7.61
	E–L	3.36 ± 1.68	0.149	−0.77 to 7.49	−0.05 ± 0.27	1.000	−0.70 to 0.61	2.11 ± 1.89	0.805	−2.53 to 6.76
	A–L	0.20 ± 1.51	1.000	−3.52 to 3.92	−0.35 ± 0.22	0.350	−0.88 to 0.19	−1.91 ± 1.65	0.747	−5.96 to 2.13
CMJ	E–A	2.45 ± 1.50	0.325	−1.24 to 6.14	0.37 ± 0.22	0.294	−0.17 to 0.90	3.67 ± 1.77	0.127	−0.69 to 8.02
	E–L	1.33 ± 1.93	1.000	−3.41 to 6.07	−0.18 ± 0.32	1.000	−0.97 to 0.60	0.22 ± 2.30	1.000	−5.43 to 5.87
	A–L	−1.12 ± 1.74	1.000	−5.40 to 3.15	−0.55 ± 0.26	0.117	−1.19 to 0.09	−3.45 ± 2.00	0.268	−8.36 to 1.46
Sprint	E–A	−0.18 ± 0.09	0.173	−0.41 to 0.05	−0.01 ± 0.01	1.000	−0.04 to 0.02	-	-	-
	E–L	−0.21 ± 0.12	0.259	−0.50 to 0.08	−0.00 ± 0.02	1.000	−0.05 to 0.04	-	-	-
	A–L	−0.03 ± 0.11	1.000	−0.29 to 0.24	0.01 ± 0.02	1.000	−0.03 to 0.04	-	-	-
YoYo distance	E–A	135 ± 111	0.687	−138 to 407	23.39 ± 15.44	0.403	−14.50 to 61.29	-	-	-
	E–L	177 ± 143	0.660	−174 to 528	10.22 ± 22.71	1.000	−45.50 to 65.94	-	-	-
	A–L	41.82 ± 129	1.000	−275 to 358	−13.17 ± 18.45	1.000	−58.44 to 32.09	-	-	-
YoYo VO^2 max	E–A	1.13 ± 0.94	0.688	−1.16 to 3.43	0.20 ± 0.13	0.402	−0.12 to 0.51	-	-	-
	E–L	1.49 ± 1.20	0.661	−1.46 to 4.43	0.09 ± 0.19	1.000	−0.38 to 0.55	-	-	-
	A–L	0.35 ± 1.08	1.000	−2.31 to 3.01	−0.11 ± 0.15	1.000	−0.49 to 0.27	-	-	-

BM: biological maturation; SD: standard deviation; CI: confidence interval; MB: medicine ball; SJ: squat jump; CMJ: counter movement jump; E: early maturers; A: average maturers; L: late maturers.

Table 5 shows the distribution (%) according to BMI classification calculated by BMI z-score according to biological maturation groups. Significant differences were found ($p < 0.036$), showing that more than half of the sample (53.4%) had a BMI of normal weight. The late maturers group was the only group that did not have any players with obesity, and although the majority were normal-weight (61.5%), the rest of the players (38.5%) were underweight. As for the early and average biological maturation groups, the BMI categories that predominated were normal-weight (45% and 55%, respectively) and overweight (40% and 25%, respectively).

Table 5. Distribution (%) according to BMI classification by biological maturation groups.

Category	Early	Average	Late	Total	X^2/p
Undernutrition	0.0%	2.5%	0.0%	1.4%	$X^2 = 16.515$; $p = 0.036$
Underweight	5.0%	7.5%	38.5%	12.3%	
Normal-weight	45.0%	55.0%	61.5%	53.4%	
Overweight	40%	25%	0.0%	24.7%	
Obesity	10%	10%	0.0%	8.2%	

4. Discussion

The main aim of this research was to observe whether there were differences, according to biological maturation, in the kinanthropometric characteristics and physical performance of young handball players. In this line, significant differences were found in basic measurements, muscle mass (MM), body mass index (BMI), Cormic Index, medicine ball throw and SJ jump, with the group of early maturers having the highest values.

Regarding the kinanthropometric characteristics, these results are similar to those found in previous studies performed both in handball players [10,42,43] and in other sports [26,27,44,45]. In both cases, athletes with early biological maturation obtained higher values in kinanthropometric characteristics. These differences between the biological maturation groups may be due to the hormonal changes that occur during this stage [11]. In fact, it has been observed in previous research that the maturational process seems to have a statistically significant influence on kinanthropometric variables [13]. The pairwise comparison of the present investigation showed significant differences between the early maturer group with the average maturer group in body mass, height, sitting height, arm span and MM, also finding, apart from those mentioned, significant differences in BMI, BMI z-value and Cormic Index when comparing the early maturers with the late maturers. More specifically, in all these differences, early maturers had higher values. This could be due to an increased concentration of sex hormones or growth hormone (GH) around the APHV [11]. Moreover, on the one hand, the differences in body mass and MM could be due to these sex hormones, as they have an important role in the accumulation of muscle tissue [11,14]. Additionally, on the other hand, the GH hormone influences height and sitting height, so it could also explain the higher values of early maturers in these variables [46]. Therefore, it seems that biological maturation influences kinanthropometric characteristics and that taking this variable into account could be a determining factor in the selection of future talents [10]. However, more research is still needed where the study population is handball players to contrast the results of the present investigation.

Regarding sports performance in physical tests, it has been observed that the increase in MM influences an improvement in power production [47]. In fact, in this research, early maturers are the ones with higher MM and better values in the medicine-ball-throwing test and SJ jump, which are related to upper and lower limb power, respectively [4]. Furthermore, the pairwise comparison showed significant differences between the early maturer group and the rest of the groups for the medicine ball throw and with the average maturer group for the SJ jump. More specifically, the players who were more advanced in biological maturation showed better values. The reason for these differences may be due to muscle development due to hormonal changes in biological maturation [11], which implies higher values of MM in early maturers, as shown in our research, and, therefore, better values in tests related to strength and power [48]. On the other hand, no significant differences were observed in the sprint test, even though it may also depend on factors related to strength and power production to some extent [44,45]. This coincides with the results found in previous studies, which observed that players who had already passed the maximum growth peak had better results in the sprint test [49] and that early maturers had better results in strength and speed tests [44]. It has been observed that other factors that could affect sprint performance are reaction time at onset, technique or sprint mechanics, among others, which could be the reason that no differences were observed in the present study [50]. The T-Half test measuring agility and the Yo-Yo test measuring endurance also showed no significant differences between the biological maturation groups. Moreover, Matthys et al. [43] also found no differences in the agility test they performed. The absence of differences could be because, in this test, performance is also influenced by other factors, such as neural control of movements or years of practice in the sport [51]. On the other hand, in the meta-analysis by Albaladejo-Saura et al. [13], they also found no differences in the Yo-Yo test, which seeks to evaluate VO^2 max as the main variable of aerobic endurance [52]. One explanation for the absence of differences between the biological maturation groups could be that an athlete’s endurance would be more influenced by the effects of training than by other variables [53–55]. In fact, it has been seen that the age at which endurance athletes have their maximum performance is far from adolescence [56]. Therefore, the hormonal development that occurs during biological maturation seems to influence physical tests where strength and power predominate, so it should be considered for future research where physical performance is also evaluated in groups of biological maturation. Even research to observe whether having teams in higher leagues influences the physical tests that evaluate the performance of an athlete. However, these differences between the results of the present study and previous literature could be due to the sample selected for each of them since Hammami et al. [49] evaluated young players from the first division and Matthys et al. [43] evaluated players that also belong to the first division and the national team. In contrast, in the present investigation, the population belonged to a regional level, competing in both provincial and autonomic leagues. These differences in the competitive level of the athletes could affect their body composition and, therefore, their performance in the physical tests [7,8].

Another aim of this research was to analyze the differences between the biological maturation groups after including the covariates age, maturity offset and diet in the model. In this line, significant differences were observed in the same kinanthropometric characteristics and in the same physical test results.

With the inclusion of the covariate age in the model, significant differences were also found for the percentage of fat mass and in all the other results of the physical tests. The effect of age on these variables has also been analyzed by other authors in other sports [26,57], observing how the values improved with increasing age, with players of early biological maturation having higher values. This similarity in the results could be due to the physiological and hormonal changes involved in the maturation process as they advance in age [11,14] since, both in our research and in the others, the sample had an age close to the APHV, causing the biological maturation in early maturers to be more advanced.

With the inclusion of the maturity offset covariate in the model, the same significant differences were found for the kinanthropometric characteristics as for the age covariate. As for the results of the physical tests, with the inclusion of the maturity offset, the same significant differences were found as age, except for the T-Half Test. That biological maturation has a significant influence due to the hormonal development occurring therein has already been discussed in previous research [13]. Furthermore, in studies such as Matthys et al. [42] or Fernandez-Romero et al. [10], where the sample was also handball players, found evidence that biological maturation was a covariate with a significant effect on the differences found for kinanthropometric characteristics and physical test results. These data reaffirm the importance of considering the maturational process of the players, especially those who are national coaches and need to choose the best players during these ages, because they influence performance in a concrete and sporadic way in these years of growth.

The inclusion of the diet covariate in the model showed the same significant differences were found as in the analysis of biological maturation, including, in this case, significant differences for the CMJ jump. These results could be because the energy and macronutrient requirements of athletes during the competitive season are very high [24]; therefore, having an optimal diet should help to improve kinanthropometric characteristics and physical test results. However, in our study, the diet variable was measured with the KIDMED questionnaire, which evaluates the Mediterranean diet quality index in children and adolescents [28]. According to this index and the mean of the maturer groups, the degree of adherence they have is medium [28]. Romero-García et al. [4], who also evaluated handball players, observed that, although the predominant grades were medium and good, this grade was not related to physical results and only to some kinanthropometric characteristics. In other studies of different sports modalities [58–60], where the degrees of adherence to the Mediterranean diet were also medium or good, they also found no relationship with the kinanthropometric characteristics or with the performance tests they performed. Therefore, having an adequate diet during the maturation process has a positive influence on kinanthropometric characteristics and on some physical test results, but more research is needed to evaluate whether the Mediterranean diet is an optimal dietary model for athletes to follow. In addition, this is the second research that has been found where the KIDMED questionnaire has been used in handball players, so more studies on this population are still needed.

The last aim of this research was to know how the players were classified according to BMI z-score according to biological maturation groups. In this line, significant differences were observed in the distribution between the groups, with the normal-weight classification being the predominant one (53.4%). In addition, it can be observed how the distribution of underweight players is decreasing as biological maturation advances, while in the case of players who are overweight, it tends to increase. These results may be influenced by the increase in body mass and height caused by biological maturation [11]. However, the BMI classification, which considers the total body mass and not in which compartments this mass is distributed [61], can be erroneous and should be used with caution when used in the athletic population since an inadequate classification and interpretation of this index by health professionals can have negative psychological connotations for adolescents and their environment [62]. In fact, in our study, it has been observed that muscle mass also increases as biological maturation advances, showing that early maturers have the most muscle mass. In previous research with adult athletes, where they also observed elevated BMI values, they concluded that it was due to the high development of muscle mass or fat-free mass, and to correctly classify the athlete population as overweight and obese, fat mass should be used [63,64]. However, these investigations were carried out in the adult athlete population, and this research is one of the first that assesses the classification of BMI in adolescent athletes and relates it to maturation. Therefore, more research is needed, both in handball players and in other sports modalities, to find out whether biological maturation influences BMI or whether the increase in BMI is only due to the development of muscle mass caused by this process [63,64].

Regarding the limitations of the study, firstly, the gold standard to evaluate the biological maturation, which is wrist and hand radiography [11], was not used to determine the maturity status of the players. This method, although it is the reference method, also has certain disadvantages since it uses X-rays and exposes the participants to certain radiation; moreover, it is a time-consuming, invasive method with a high cost [65]. Another non-invasive option, easy to apply and widely used in previous research with athletes [13,26], is maturity estimation equations based on regression equations. The one used in this study was the one described by Mirwald et al. [34], as it has been one of the most widely used in the adolescent athlete population in different disciplines [13]. In addition, the considerations identified in the literature were followed to avoid the inclusion of errors in the estimation of the maturity offset [65]. The sample size and selection of the same were also a limitation, which limits the extrapolation of the results to populations that do not have similar characteristics, and the study design, which, being cross-sectional, was not possible to follow up on how biological maturation affects throughout adolescence. Another limitation of the study is that only biological maturation and diet have been considered as factors that influence kinanthropometry and physical fitness characteristics, but sports performance is a multifactorial issue where other factors, such as genes, lifestyle, socio-economic variables, geographics issues, habits, diet or the age of the parents when the child was born, can have a great influence on the child's development. On the other hand, the KIDMED questionnaire does not report on the amount of food consumed.

Therefore, as future lines of research, all these limitations could be addressed with larger samples in longitudinal studies, observing how the maturational process influences kinanthropometric characteristics and performance and carrying out questionnaires that do assess the amount of food ingested. In addition, it would also be interesting to observe the evolution of BMI in this population as biological maturation progresses using appropriate tools, such as the BMI z-score. Additionally, as a practical application of this study, the results presented provide handball coaches of infant and cadet categories with the importance of biological maturation on kinanthropometric and physical condition variables, and it is not advisable to make comparisons among players without considering the effect of biological maturation. At the level of organization of handball competitions, it should be taken into account that the different growth rates shown at this stage can produce competitive disadvantages for players who are later, so regulations can be established in competitions to encourage competition to take place on equal terms and late maturers also have opportunities to participate, as has been proposed in other sports [26,27]. Furthermore, another practical application for coaches and even for other researchers who evaluate and interpret BMI is that they should use this variable with caution in the adolescent population, as is the case with the adult sports population, since the different body compartments that make up body mass must be taken into account [61,63].

5. Conclusions

In conclusion, there are differences according to biological maturation in most of the kinanthropometric characteristics and in the physical tests related to strength and power, highlighting that players whose maturation process is more advanced weigh more, have a greater height, have more muscle mass and have better values in the medicine-ball-throwing tests and the SJ jump. Age, maturity offset and diet significantly influence biological maturation, so these covariates should be taken into account when making evaluations to predict the future performance of players. Finally, significant differences were found between biological maturation groups in the distribution of BMI classification, with the normal-weight grade predominating.

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Informed Consent Statement: Informed consent was obtained from the parents or legal tutors of all subjects involved in the study, as they were under 18 years old.

Data Availability Statement: The data are available from the authors on request from the corresponding author.

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