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Article

The Body Composition Effects on Physical Tests and On-Court Game Performance of U-14 Elite Portuguese Basketball Players

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Abstract: The purpose of this study was to clarify the effect of body composition, particularly body fat percentage (BF%) and fat-free mass (FFM), on physical fitness and players' on-court performance in U-14 elite Portuguese basketball players. A total of 166 male basketball players (age, 13.80 ± 0.38 years) and 131 female basketball players (age, 13.57 ± 0.55 years) from under-14 (U-14) elite regional teams were evaluated. Differences between body composition groups, regarding physical tests and performance-related variables, adjusted for years at age peak velocity (YAPHV), were evaluated using ANCOVA tests, for male and female players. Results showed that: (i) low body fat male players jumped significantly higher and had more relative jumping power, were faster, and had better game performance than higher body fat male players, (ii) higher fat-free mass male players revealed significantly higher upper body strength and gained more rebounds than other players, (iii) higher body fat female players threw the medicinal ball further than other female players, and (iv) higher fat-free mass female players had significantly more upper body strength and jumped significantly lower than low fat-free mass female players. In conclusion, BF% seems to be oppositely associated with physical fitness and on-court performance in male basketball players, and FFM seems to be related to upper body strength in both sexes. Coaches should promote interventions that target lower BF% and ideal FFM mass values to improve physical and on-court performance in youth basketball.

Keywords: body composition; physical fitness; game performance; youth basketball

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1. Introduction

Basketball is a physically demanding sport, which requires players to participate in repeated bouts of intense actions (e.g., sprinting, shuffling, and jumping) interspersed with short low-intensity actions (e.g., walking, jogging) and recovery [1–5]. As a result, basketball players develop several fitness attributes, including muscular power [5–7], speed [6,8]) and agility [7,8]. Body size (i.e., height, body mass) and body composition also appear to be determinants for adult [9–11] and youth basketball performance [12–14].

The relationships between body composition (BC) and performance tests have been studied in several sports [15–18], and previous research has shown that body fat percentage (BF%) and fat-free mass (FFM) levels (two common indicators of body composition) varied according to the sport and sport-specific success [15], particularly in basketball [19]. In a recent study with female college athletes from six different sports (basketball, volleyball, gymnastics, lacrosse, rowing, and soccer), gymnastics and basketball athletes displayed the lowest BF% across the six sports, while basketball players had the highest FFM of all sports [15]. Other studies found that long-distance runners were characterized by relatively low BF% and low FFM [20], throwers had high body adiposity and a high level of FFM, while swimmers demonstrated higher values of body fat [21]. Previous studies found that increased BF% was negatively correlated with total minutes played by ice hockey players [22] and with the running performance of top-class runners [20]. In the meantime, increased FFM was positively correlated with the power clean test of lacrosse college players [23]. It has also been shown that a high FFM predicted strength and power performance in highly trained football athletes [24]. In youth basketball, BF% was negatively correlated with speed, agility, and anaerobic tests performed with and without a ball [8]. The overweight U-12 players showed worse performance in running (sprint and endurance) and jumping (CMJ), while U-18 overweight practitioners had worse endurance than normal-weight players [25].

Besides influencing physical test results, BC also has a strong impact on game performance and players' competitive level. A recent meta-analysis pointed out that BF varies according to players' competitive level, with international players showing less BF than regional players [19]. A previous study with Portuguese U-14 players selected for regional teams revealed that athletes from lower-ranked teams had higher values of BF% than those from finalist teams, suggesting that BF could influence the team's final classification [12]. In basketball, previous studies have assessed the players' game performance through the performance index rating (PIR) and points scored per game [13,14]. The knowledge of the relationship between BC and on-court and physical test performance may help coaches to guide the training program and help with players' athletic success. In basketball, where body size (i.e., body mass and height) is definitively an advantage, the athletes tend to be taller, heavier and have a larger FFM than other athletes [5,21]. Previous research has evaluated the ideal physiological and anthropometric profiles of successful adult and professional basketball players [9,11]. However, no study relating BC with fitness tests and on-court performance has been conducted in youth basketball.

In accordance, the purpose of this study was to clarify the impact that BF% and FFM have on conditioning test results (i.e., speed, agility, upper and lower body strength) as well as on players' on-court performance, evaluated by PIR and points per game (PPG) in U-14 elite Portuguese basketball players. It was hypothesized that BF% and FFM would play a significant role in fitness test results and on-court performance, with lower BF% and higher FFM players showing better physical test results and higher PIR than higher BF% players.

2. Methods

2.1. Subjects

A total of 166 male basketball players (age, 13.80 $\pm$ 0.38 years) and 131 female basketball players (age, 13.57 $\pm$ 0.55 years) of under-14 (U-14) elite regional teams (i.e., teams constituted by selected players from each administrative region) participated in the study. All elite regional teams participated in the Portuguese Festival of Youth Basketball, an annual tournament organized by the Portuguese Basketball Federation for U-14 elite regional teams.

All participants received clear guidelines on the objectives, procedures, and methodology of this study. Only the players whose parents or legal guardians gave their written consent participated in the study. The study was authorized by the Ethics Committee of the Faculty of Human Kinetics—Universidade de Lisboa (No. 53/2015) and by the Ethics Committee of the Faculty of Physical Education and Sport—Universidade Lusófona (Ph.D. ID, 101516444; 25-02-2016), and was performed according to the 2013 Helsinki Declaration.

2.2. Testing Procedures

All the data related to players' morphologic and fitness characteristics were collected by the researchers. The measurements took place on the first day of the tournament to avoid the influence of players' fatigue on the results of the measurements. However, some players were measured after the competition had started. In these cases, it was guaranteed that the evaluations were conducted at least two hours after the game had been played. The test battery used in the study covered maturity status, and morphological and fitness evaluations, which have already been described in detail in a previous paper [12]. Anthropometric measures were undertaken before functional skills tests.

2.3. Players' Basketball Performance

Performance was assessed in terms of minutes played (i.e., expressed as average minutes per game), points scored (i.e., expressed as the average points per game), rebounds captured (i.e., expressed as the average points per game), and the performance index rating (PIR) of players during the championship. PIR is a basketball statistical formula that is used by the International Basketball Association (FIBA), as well as various European national domestic leagues, to measure the overall game performance of a basketball player. These values were calculated with the data recorded by the officials of the FPB using the following formula: PIR = (points + rebounds + assists + steals + blocks + fouls drawn) − (missed field goals + missed free throws + turnovers + shots rejected + fouls committed).

2.4. Age and Maturity Evaluation

Chronological age (CA, in decimals) was calculated as the difference between the date on which the anthropometric measures were taken and the date of birth. Maturity offset (years before or after the age at peak height velocity, i.e., YAPHV) was predicted from a sex-specific equation [26]. The applicability of the method appears to be useful during the growth spurt, approximately between 12 and 15 years of age [27].

2.5. Morphological Evaluation

Body mass, height, sitting height, and three skinfolds—triceps (TRI), calf (GML), and subscapular (SBS)—were measured according to the International Society for the Advancement of Kinanthropometry guidelines [28]. Body mass was measured with a Secca body scale, model 761 7019009. to the nearest 0.5 kg, and stature and sitting height were measured with a Siber–Hegner anthropometric kit to the nearest 0.1 cm. All measurements were conducted by a Level 2 ISAK anthropometric technician. The intra-observer technical errors of measurements (%TEM) (and coefficient of reliability—R) were well-below the accepted maximum for stature ($R \geq 0.98$), 5% for skinfolds ($0.90 \leq R \leq 0.98$), and 1% for breadths and girths ($0.92 \leq R \leq 0.98$) [28]. The body composition analysis included the evaluation of body fat percentage (BF%) and fat-free mass (FFM, kg), estimated from skinfold values. The BF% was calculated as the arithmetic mean of the BF% values obtained through the equations proposed by Lohman (Equation (1): $BF\% = 1.35 \times (TRI + SBS) - 0.012 \times (TRI + SBS)^2 - I$, and I = intercept based on sex, age, and ethnicity) [29] and Slaughter and colleagues (Equation (2) for boys: $BF\% = 0.735 \times (TRI + GML) + 1$; Equation (3) for girls: $BF\% = 0.610 \times (TRI + SBS) + 5.1$) [30]. Body mass index (BMI) was calculated using the formula: $BMI = \text{Body mass}/\text{height}^2$ (kg/m^2). Body fat index (BFI) was calculated using the formula: $BFI = \text{Body fat}/\text{height}^2$ (kg/m^2).

2.6. Fitness Evaluation

Before the fitness tests, all participants performed a standard 20-min warm-up routine (slow jogging, followed by static and dynamic stretching) supervised by the researchers. The players were allowed 10-min of passive rest between tests, as well as water breaks and extra rest time. Each participant was verbally instructed and encouraged to give his/her maximum effort. Three trials were completed for each test. The first was a practice trial for the familiarization with the test and the second and third trials were retained for analysis. All players completed seven fitness tests, from which nine variables were collected for analysis. The established order of physical tests allowed for avoiding performing two consecutive tests for the upper or lower body. In each team, due to competition constraints, the players were divided into groups of four elements and went through the established order. The researchers collected all data.

Speed test. The 20 m speed test was performed and consisted of a 20 m linear sprint effort [31]. The time of the speed test was recorded in seconds and hundredths of a second, using photoelectric cells (Wireless Sprint system, Brower Timing Systems, Salt Lake City, UT, USA), and the best time of two attempts was registered.

T-Test. The T-test was used for the change of direction (COD) ability assessment [6,31]. The time was recorded in seconds and hundredths of a second, using photoelectric cells (Wireless Sprint system, Brower Timing Systems, Salt Lake City, UT, USA), and the best time of two attempts was registered.

Jump tests. The vertical jumping ability was tested using the countermovement jump (CMJ) and countermovement jump with arms swing (CMJ-S) tests [32]. The height (cm) and relative power (Watts/kilograms, W/kg) of vertical jumps were recorded with a Chronojump measurement technology (Bosco System, Globus, Italy). The best of two attempts was considered. In both tests, the retry interval was 10 s.

Two-kilogram medicine ball throw. The upper-limb explosive strength was tested using the 2 kg medicine ball throw (MBT) [6]. Participants started the test from a sitting position with their back against the wall using a release from the chest. The distance (cm) attained in the best of two attempts was recorded.

Handgrip strength. The handgrip (HG) strength was assessed with a handgrip test using a dynamometer (Takei Physical Fitness Test, TKK 5001, GRIP—A, Tokyo, Japan) [33]. Subjects performed the test twice with each hand, and the sum of the best results, achieved by the left and right hands, was considered (in kg).

Sit and reach test. Flexibility was assessed using the sit and reach test [34]. The score of the test was recorded to the nearest centimeter as the distance reached by the tip of the fingers. The vertical line of the feet' soles was considered as a plane counted as 0 cm. Negative and positive centimeters were considered when the players reached forward, respectively, before and after this vertical plane.

2.7. Criteria for Division into Groups

Based on preliminary BC measurements (i.e., BF% and FFM), it was assumed that the average (normal) BC level was between the 25th and 75th percentiles, the lower level was below the 25th percentile, and the higher level was above the 75th percentile. The following inclusion criteria were established for each group of participants: (i) the lower body fat group (LBF) and lower fat-free mass group (LFFM) had values of BF% and FFM, respectively, below the 25th percentile, (ii) the regular body fat group (RBF) and regular fat-free mass group (RFFM) had values of BF% and FFM, respectively, between the 25th and the 75th percentiles, and (iii) the higher body fat group (HBF) and higher fat-free mass group (HFFM) had values of BF% and FFM, respectively, above the 75th percentile.

3. Statistical Analyses

All the analyses were performed using the Statistical Package for the Social Sciences (SPSS, Version 28.0, IBM SPSS, Chicago, IL, USA). Statistical significance was set a priori at $p < 0.05$. Normality and homogeneity of variances were assessed using Shapiro–Wilk and Levene tests, respectively. Descriptive statistics (mean, M; standard deviation, SD) for male and female basketball players were calculated for all tested variables. The intraclass correlation coefficient [35] was calculated for the 20 m speed test, T-test, jump tests (i.e., CMJ and CMJ-S height and relative power), the 2 kg MBT test, HG test, and the sit and reach test (see Table 1). Partial correlations (r) between body composition (BM, %BF, FFM) and fitness test and game performance variables, controlling the effect of YAPHV, were calculated to identify the magnitude and direction of the possible relationships. The magnitude of the correlations was classified as small if $0.10 \leq |r| < 0.30$, medium if $0.30 \leq |r| < 0.50$, and large if $|r| \geq 0.50$ [36].

Table 1. Intraclass correlation statistics to assess intra-rater reliability in the fitness tests.

Variables	ICC [a]	95% CI		*F* Test with True Value 0			
		Lower Bound	Upper Bound	Value	df1	df2	*p*
V20-m (s)	0.859	0.456	0.941	23.243	347	347	<0.001
T-test (s)	0.856	0.276	0.948	27.328	195	195	<0.001
CMJ height (cm)	0.934	0.581	0.976	59.326	376	376	<0.001
CMJ rel. power (W/kg)	0.932	0.610	0.975	54.988	304	304	<0.001
CMJ-S height (cm)	0.944	0.526	0.982	80.571	376	376	<0.001
CMJ-S rel. power (W/kg)	0.846	0.724	0.905	14.873	287	287	<0.001
2 kg MBT (m)	0.921	0.407	0.974	56.344	385	385	<0.001
HG right hand (kg)	0.960	0.664	0.987	107.427	172	172	<0.001
HG left hand (kg)	0.962	0.772	0.986	95.822	173	173	<0.001
Sit and reach test (cm)	0.952	0.437	0.985	108.977	381	381	<0.001

Key: [a] ICC estimates and their 95% confidence intervals were calculated based on a single measure, absolute agreement, two-way mixed-effects model. CI = confidence interval; CMJ = countermovement jump; CMJ-S = countermovement jump with arms swing; HG = handgrip; ICC = intraclass correlation coefficient; MBT = medicine ball throw; V20-m = 20 m speed test.

The 25th and 75th percentiles were calculated for BF% and FFM and players were divided into groups according to the criteria mentioned above. Analysis of covariance (ANCOVA) tests were used to test the effect of BF% groups and FFM groups on each morphological, fitness, and on-court game performance indicator after statistically controlling for the effect of YAPHV. Significant ANCOVA tests were followed by post hoc tests with Bonferroni adjustment. The effect size was estimated using partial eta-squared (partial η^2), and the magnitude of these results was classified according to the Cohen [36] benchmarks, i.e., [0.01, 0.06] (small), [0.06, 0.14] (moderate), and $\geq$0.14 (large).

4. Results

The mean and SD of the subjects' age, height, BM, BMI, BF%, relative BF, FFM, 20 m speed test, T-test, height and relative power of jump tests (CMJ and CMJ-S), handgrip test, 2 kg MBT test, and game performance variables are presented in Table 2.

Table 2. Morphological, fitness, and game performance descriptive statistics (mean ± SD) of elite male and female U-14 Portuguese basketball players.

Variables	Male Players (*n* = 166)		Female Players(*n* = 131)	
	Mean	SD	Mean	SD
Basketball Experience (years)	5.29	±2.57	4.76	±2.48
CA (years)	13.80	±0.38	13.57	±0.55
YAPHV (years)	0.53	±0.76	1.64	±0.61
Morphology				
Body mass (kg)	60.1	±10.1	55.6	±9.4
Stature (cm)	173.2	±8.67	164.4	±6.9
BMI (kg/m^2)	19.90	±2.27	20.47	±2.58
%BF	16.90	±4.63	23.36	±4.56
BFI (kg/m^2)	3.44	±0.10	4.86	±0.13
FFM (kg)	49.72	±7.22	42.30	±5.55

Table 2. *Cont.*

Variables	Male Players (*n* = 166)		Female Players(*n* = 131)	
	Mean	SD	Mean	SD
Fitness				
V20-m (s)	3.35	±0.23	3.56	±0.19
T-test (s)	10.40	±0.68	11.20	±0.60
CMJ height (cm)	30.01	±5.12	23.81	±3.69
CMJ rel. power (W/kg)	12.06	±1.20	10.85	±0.85
CMJ-S height (cm)	35.73	±5.65	27.60	±4.08
CMJ-S rel. power (W/kg)	13.17	±1.25	11.69	±0.90
SUM HG (kg)	71.3	±14.8	56.7	±9.5
2 kg MBT (m)	5.00	±0.75	3.86	±0.43
Sit and reach (cm)	−1.48	±7.91	2.87	±7.66
Game Performance				
PIR/game	2.25	±3.37	2.10	±3.08
PIR/min	0.13	±0.24	0.11	±0.20
Points/game	3.82	±2.60	3.80	±2.84
Points/min	0.26	±0.15	0.24	±0.15
Rebounds/game	2.84	±1.87	2.64	±1.55
Game time (min)	14.12	±3.76	14.68	±4.32

Key: BMI = body mass index; BF = body fat; CA = chronological age; CMJ = countermovement jump; CMJ-S = countermovement jump with arms swing; SUM HG = sum of right and left handgrips; MBT = medicine ball throw; PIR = performance index rating; V20-m = 20 m speed test; YAPHV = years from the age at peak height velocity; %BF = percent body fat.

4.1. Partial Correlations between Body Composition Indicators, Fitness Attributes, and Performance-Related Parameters

The values of correlations between body composition indicators, fitness attributes, and performance-related indicators are presented in Table 3.

Table 3. Partial correlations between body composition (BM, %BF, FFM) and fitness test and game performance variables, controlling for the effect of YAPHV.

	Male Players			Female Players		
Variables	BM	%BF	FFM	BM	%BF	FFM
Fitness						
V20-m (s)	0.210 *	0.238 *	0.076	0.197	0.145	0.143
T-test (s)	0.233 *	0.223 *	0.115	0.328 **	0.210	0.293 **
CMJ height (cm)	−0.226 *	−0.352 **	−0.039	−0.336 **	−0.272 *	−0.284 **
CMJ rel. power (W/kg)	−0.235 *	−0.274 **	−0.116	−0.409 **	−0.313 **	−0.357 **
CMJ-S height (cm)	−0.256 **	−0.381 **	−0.052	−0.354 **	−0.214 *	−0.333 **
CMJ-S rel. power (W/kg)	−0.255 **	−0.287 **	−0.128	−0.417 **	−0.255 *	−0.393 **
SUM HG (kg)	0.344 **	0.148	0.350 **	0.448 **	0.336 **	0.422 **
MBT (m)	0.245 *	−0.015	0.346 **	0.563 **	0.432 **	0.502 **
Sit and reach (cm)	−0.083	−0.061	−0.065	−0.042	0.151	−0.124
Game Performance						
PIR/game	−0.103	−0.261 **	0.088	0.101	0.019	0.114
PIR/min	0.086	−0.269 **	0.123	0.124	0.045	0.123
Points/game	−0.135	−0.200 *	−0.011	−0.008	−0.071	0.029
Points/min	−0.108	−0.175	0.007	0.048	−0.035	0.085
Rebounds/game	0.184	0.070	0.307 **	0.104	0.010	0.113
Game Time (s)	−0.057	−0.199 *	0.075	−0.105	−0.122	−0.081

Key: BM = body mass; CMJ = countermovement jump; CMJ-S = countermovement jump with arms swing; FFM = fat-free mass; MBT = medicine ball throw; PIR = performance index rating; SUM HG = sum of right and left handgrip; V20-m = 20 m speed test; YAPHV = years from the age at peak height velocity; %BF = percent body fat. * $p \leq 0.01$, ** $p \leq 0.001$.

The analysis of correlations between BM and fitness tests results of male players, after adjusting for YAPHV, showed a significant moderate positive correlation of BM with SUM HG (r = 0.344, $p \leq 0.001$), a small positive correlation with MBT (r = 0.245, $p \leq 0.01$), speed (r = 0.210, $p \leq 0.01$), and COD speed (r = 0.233, $p \leq 0.01$), as well as a small negative correlation with jump height (r = −0.226, $p \leq 0.01$; r = −0.256, $p \leq 0.01$; for CMJ and CMJ-S, respectively) and relative power (r = −0.235, $p \leq 0.01$; r = −0.33, $p \leq 0.01$; for CMJ and CMJ-S, respectively). When controlling for the YAPHV effect, BF% showed a significant small correlation with the 20 m speed test (r = 0.238, $p \leq 0.01$) and the T-test (r = 0.223, $p \leq 0.01$), a significant negative small correlation with jumps' relative power (r = −0.274, $p \leq 0.001$; r = −0.287, $p \leq 0.001$; for CMJ and CMJ-S, respectively), and a significant negative moderate correlation with jump height (r = −0.352, $p \leq 0.001$; r = −0.381, $p \leq 0.001$; for CMJ and CMJ-S, respectively). In addition, when adjusting for the YAPHV effect, FFM showed a significant moderate positive correlation with SUM HG (r = 0.350, $p \leq 0.001$) and MBT (r = 0.346, $p \leq 0.001$). Regarding game performance variables, and after controlling for YAPHV, BF% showed a significant small negative correlation with PIR/game (r = −0.261, $p \leq 0.001$), PIR/min (r = −0.269, $p \leq 0.001$), points/game (r = −0.200, $p \leq 0.01$), and minutes played (r = −0.199, $p \leq 0.01$). A significant moderate positive correlation was reported between FFM and the number of rebounds per game (r = 0.307, $p \leq 0.01$), after adjusting for YAPHV.

In female players, the analysis of correlations between BM and fitness tests results, after adjusting for YAPHV, demonstrated a significant large positive correlation of BM with MBT (r = 0.563, $p \leq 0.001$), a significant moderate positive correlation with SUM HG (r = 0.448, $p \leq 0.001$) and T-test (r = 0.328, $p \leq 0.001$), as well as a significant moderate negative correlation with both jump height (r = −0.336, $p \leq 0.001$; r = −0.354, $p \leq 0.001$; for CMJ and CMJ-S, respectively) and relative power (r = −0.409, $p \leq 0.001$; r = −0.417, $p \leq 0.01$; for CMJ and CMJ-S, respectively). Further, and after controlling for YAPHV, BF% showed a significant negative small correlation with both jump height (r = −0.272, $p \leq 0.01$; r = −0.214, $p \leq 0.01$; for CMJ and CMJ-S, respectively) and CMJ-S relative power (r = −0.255, $p \leq 0.01$), a significant negative moderate correlation with CMJ relative power (r = −0.313, $p \leq 0.001$), and a significant moderate correlation with SUM HG (r = 0.336, $p \leq 0.001$) and MBT (r = 0.432, $p \leq 0.001$). In addition, after adjusting for the YAPHV effect, FFM showed a significant small positive correlation with T-test (r = 0.293, $p \leq 0.001$), a significant negative correlation with both jump height (r = −0.284, $p \leq 0.01$; r = −0.333, $p \leq 0.001$; for CMJ and CMJ-S, respectively) and relative power (r = −0.357, $p \leq 0.001$; r = −0.393, $p \leq 0.001$; for CMJ and CMJ-S, respectively), a significant moderate positive correlation with SUM HG (r = 0.422, $p \leq 0.001$), and a large positive correlation with MBT (r = 0.502, $p \leq 0.001$). Finally, no significant correlations were reported between BC variables (BM, BF%, and FFM) and game performance indicators, after controlling for the effect of YAPHV, in female players.

4.2. Differences between Body Composition Groups Regarding Physical Tests and Performance-Related Variables

Descriptive statistics and ANCOVA results (with YAPHV as a covariate) concerning the morphological attributes, fitness performance measures, and on-court game performance indicators for BF% and FFM groups, are presented in Table 4 for male players, and in Table 5 for female players.

Table 4. Descriptive statistics and results of ANCOVA (with YAPHV as a covariate) testing the effect of BF% and fat-free mass (FFM) groups in fitness and performance variables of U-14 male basketball players.

	ANCOVA (YAPHV [a])			**Effect of BF% Groups**			**ANCOVA (YAPHV [a])**			**Effect of FFM Groups**		
	LBF (n = 41)	**RBF (n = 84)**	**HBF (n = 41)**	F	p	η^2	**LFFM (n = 41)**	**RFFM (n = 84)**	**HFFM (n = 41)**	F	p	η^2
Basketball experience	5.81 ± 0.40	5.16 ± 0.28	5.05 ± 0.40	1.125	0.327	0.014	5.69 ± 0.55	5.32 ± 0.28	4.85 ± 0.52	0.285	0.594	0.002
CA (years)	13.88 ± 0.05	13.72 ± 0.04	13.80 ± 0.05	1.342	0.264	0.016	14.05 ± 0.06 ∞	13.79 ± 0.0.04 ∞	13.60 ± 0.06 ∞	8.173	<0.001	0.092
Morphology												
Body Mass (kg)	55.7 ± 0.8 ∞	59.6 ± 0.6 ∞	65.6 ± 0.8 ∞	39.779	<0.001	0.329	52.0 ± 1.0 ∞	60.4 ± 0.5 ∞	67.8 ± 1.0 ∞	40.037	<0.001	0.331
Height (cm)	173.4 ± 0.7	173.2 ± 0.5	173.1 ± 0.7	0.061	0.941	0.001	170.1 ± 0.9 ∞	173.2 ± 0.4 ∞	176.3 ± 0.8 ∞	9.772	<0.001	0.108
BMI (kg/m^2)	18.40 ± 0.26 ∞	19.78 ± 0.18 ∞	21.73 ± 0.26 ∞	40.555	<0.001	0.334	17.82 ± 0.39 ∞	20.14 ± 0.21 ∞	21.58 ± 0.38 ∞	16.817	<0.001	0.172
%BF	11.99 ± 0.35 ∞	16.21 ± 0.25 ∞	23.23 ± 0.35 ∞	263.802	<0.001	0.765	16.39 ± 0.99	16.87 ± 0.51	17.49 ± 0.94	0.240	0.787	0.003
BFI (kg/m^2)	2.22 ± 0.11 ∞	3.22 ± 0.07 ∞	5.11 ± 0.11 ∞	169.850	<0.001	0.677	2.97 ± 0.27 #	3.46 ± 0.14	3.86 ± 0.26	2.020	0.136	0.024
FFM (kg)	48.96 ± 0.60	49.92 ± 0.42	50.05 ± 0.60	1.085	0.340	0.013	43.20 ± 0.57 ∞	50.00 ± 0.29 ∞	55.65 ± 0.54 ∞	89.037	<0.001	0.524
Fitness												
V20-m (s)	3.30 ± 0.03 #	3.33 ± 0.02 †	3.44 ± 0.03	4.778	0.010	0.056	3.31 ± 0.05	3.31 ± 0.03 †	3.45 ± 0.05	3.652	0.028	0.043
T-Test (s)	10.24 ± 0.11 #	10.36 ± 0.07 †	10.66 ± 0.11	4.306	0.015	0.050	10.29 ± 0.14 #	10.26 ± 0.07 †	10.81 ± 0.13	7.116	0.001	0.081
CMJ Height (cm)	32.11 ± 0.74 #	30.06 ± 0.52 †	27.80 ± 0.75	8.194	<0.001	0.092	30.94 ± 1.06	30.37 ± 0.54	28.32 ± 1.00	1.690	0.118	0.020
CMJ Rel. Power (W/kg)	12.55 ± 0.18 *#	12.03 ± 0.13	11.69 ± 0.18	5.800	0.004	0.067	12.36 ± 0.25	12.19 ± 0.13 †	11.57 ± 0.24	2.523	0.083	0.030
CMJ-S Height (cm)	38.03 ± 0.82 ∞	35.93 ± 058 ∞	33.01 ± 0.83 ∞	9.243	<0.001	0.102	36.27 ± 1.17	36.32 ± 0.60 †	33.96 ± 1.11	1.839	0.162	0.022
CMJ-S Rel. Power (W/kg)	13.66 ± 0.19 *#	13.13 ± 0.13	12.74 ± 0.19	5.926	0.003	0.068	13.39 ± 0.26	13.30 ± 0.13	12.67 ± 0.25	2.583	0.079	0.031
SUM HG (kg)	69.1 ± 1.9 #	71.0 ± 1.3	74.3 ± 1.9	1.829	0.154	0.023	63.6 ± 2.6 ∞	72.1 ± 1.3 ∞	77.5 ± 2.6 ∞	5.553	0.005	0.064
2 kg MBT (cm)	4.97 ± 0.08	5.06 ± 0.06	4.93 ± 0.08	0.834	0.436	0.010	4.75 ± 0.12 *	5.08 ± 0.06	5.10 ± 0.11	3.070	0.049	0.037
Sit and reach (cm)	−0.97 ± 1.24	−1.34 ± 0.87	−2.31 ± 1.25	0.333	0.717	0.004	−0.86 ± 1.70	−1.39 ± 0.87	−2.27 ± 1.61	0.141	0.868	0.002
Game Performance												
PIR/game	3.42 ± 0.48 #	2.27 ± 0.33 †	0.97 ± 0.48	6.556	0.002	0.075	2.02 ± 0.67	2.14 ± 0.35	2.70 ± 0.64	0.306	0.737	0.004
PIR/min	0.20 ± 0.04 #	0.14 ± 0.03 †	0.03 ± 0.04	5.888	0.003	0.068	0.08 ± 0.05	0.13 ± 0.03	0.18 ± 0.05	0.661	0.518	0.008
Points/game	4.63 ± 0.39 #	3.82 ± 0.27	3.03 ± 0.39	4.207	0.017	0.049	3.69 ± 0.55	3.86 ± 0.28	3.88 ± 0.52	0.038	0.963	0.000
Points/min	0.31 ± 0.02 #	0.26 ± 0.02	0.22 ± 0.02	3.763	0.025	0.044	0.23 ± 0.03	0.26 ± 0.01	0.28 ± 0.03	0.327	0.721	0.004
Rebounds	3.10 ± 0.26	2.79 ± 0.18	2.67 ± 0.26	0.720	0.488	0.009	1.97 ± 0.35 ∞	2.80 ± 0.18 ∞	3.80 ± 0.33 ∞	5.250	0.006	0.061
Game time (m)	15.29 ± 0.57 #	14.10 ± 0.40	12.98 ± 0.57	4.024	0.020	0.047	13.86 ± 0.80	14.09 ± 0.41	14.42 ± 0.76	0.096	0.909	0.001

Key: * Significant difference between LFFM and RFFM groups, $p < 0.05$. # Significant difference between LFFM and HFFM groups, $p < 0.05$. † Significant difference between RFFM and HFFM groups, $p < 0.05$. ∞ Significant difference between all groups, $p < 0.05$. [a] Covariate appearing in the model is evaluated at the following value: YAPHV = 0.528 years. BFI = body fat index; BMI = body mass index; CA = chronological age; CMJ = countermovement jump; CMJ-S = countermovement jump with arms swing; FFM = fat-free mass; HBF = higher body fat; LBF = low body fat; MBT = medicine ball throw; PIR = performance index rating; RBF = regular body fat; SUM HG = sum of right and left handgrip; SJ = squat jump; V20-m = 20 m speed test; YAPHV = years from age at peak height velocity; %BF = percent body fat; LFFM = lower FFM; RFFM = regular FFM; HFFM = higher FFM.

Table 5. Descriptive statistics and results of ANCOVA (with YAPHV as a covariate) testing the effect of BF% and fat-free mass (FFM) groups in fitness and performance variables of U-14 female basketball players.

	ANCOVA (YAPHV [a])			Effect of BF% Groups			ANCOVA (YAPHV [a])			Effect of FFM Groups		
	LBF (n = 33)	RBF (n = 65)	HBF (n = 33)	F	p	η^2	LFFM (n = 33)	RFFM (n = 65)	HFFM (n = 33)	F	p	η^2
Basketball experience	5.19 ± 0.46	4.79 ± 0.31	4.33 ± 0.47	0.798	0.452	0.013	5.01 ± 0.54	5.20 ± 0.31 †	3.72 ± 0.52	3.174	0.045	0.049
CA (years)	13.52 ± 0.06	13.62 ± 0.04 †	13.43 ± 0.06	3.280	0.041	0.049	13.79 ± 0.07 ∞	13.60 ± 0.04 ∞	13.28 ± 0.07 ∞	11.573	<0.001	0.154
Morphology												
Body Mass (kg)	50.8 ± 1.0 ∞	55.2 ± 0.7 ∞	61.0 ± 1.0 ∞	24.154	<0.001	0.276	49.5 ± 1.0 ∞	54.0 ± 0.6 ∞	64.7 ± 1.0 ∞	55.696	<0.001	0.467
Height (cm)	165.4 ± 0.7 *	163.7 ± 0.5	165.0 ± 0.7	2.529	0.084	0.038	163.7 ± 0.8	164.4 ± 0.5	165.3 ± 0.8	0.859	0.426	0.013
BMI (kg/m^2)	18.51 ± 0.35 ∞	20.60 ± 0.25 ∞	22.17 ± 0.37 ∞	24.144	<0.001	0.275	18.34 ± 0.40 ∞	20.02 ± 0.23 ∞	23.47 ± 0.38 ∞	39.895	<0.001	0.386
%BF	17.97 ± 0.38 ∞	23.46 ± 0.26 ∞	28.53 ± 0.38 ∞	179.259	<0.001	0.738	24.00 ± 0.87	22.47 ± 0.51 †	24.45 ± 0.82	3.148	0.046	0.047
BFI (kg/m^2)	3.37 ± 0.14 ∞	4.85 ± 0.10 ∞	6.38 ± 0.14 ∞	103.186	<0.001	0.619	4.47 ± 0.26 #	4.56 ± 0.15 †	5.86 ± 0.24	11.244	<0.001	0.150
FFM (kg)	41.47 ± 0.67	42.25 ± 0.46	43.25 ± 0.67	1.677	0.191	0.026	37.44 ± 0.49 ∞	41.71 ± 0.28 ∞	48.34 ± 0.46 ∞	111.910	<0.001	0.638
Fitness												
V20-m (s)	3.55 ± 0.03	3.55 ± 0.02	3.61 ± 0.03	1.129	0.327	0.017	3.59 ± 0.04	3.54 ± 0.02	3.58 ± 0.04	0.702	0.498	0.011
T-Test (s)	11.05 ± 0.11 #	11.19 ± 0.07	11.38 ± 0.11	2.245	0.110	0.034	11.18 ± 0.13	11.15 ± 0.08	11.31 ± 0.12	0.660	0.518	0.010
CMJ Height (cm)	24.77 ± 0.64 #	23.83 ± 0.45	22.80 ± 0.65	2.198	0.115	0.033	24.25 ± 0.77	24.17 ± 0.45	22.65 ± 0.73	1.669	0.193	0.026
CMJ Rel. Power (W/kg)	11.03 ± 0.1 #	10.87 ± 0.1	10.60 ± 0.1	2.432	0.092	0.037	11.02 ± 0.18	10.93 ± 0.10 †	10.54 ± 0.17	2.202	0.115	0.034
CMJ-S Height (cm)	28.47 ± 0.73	27.45 ± 0.50	27.03 ± 0.73	1.013	0.366	0.016	28.22 ± 0.84 #	28.36 ± 0.49 †	25.50 ± 0.79	4.910	0.009	0.072
CMJ-S Rel. Power (W/kg)	11.88 ± 0.16	11.67 ± 0.11	11.54 ± 0.16	1.069	0.346	0.017	11.88 ± 0.19 #	11.85 ± 0.11 †	11.20 ± 0.18	5.225	0.007	0.076
SUM HG (kg)	54.6 ± 1.4	57.3 ± 1.0	57.5 ± 1.4	1.470	0.234	0.023	54.1 ± 1.6 #	56.3 ± 0.9 †	60.0 ± 1.6	2.953	0.056	0.044
MBT (cm)	3.74 ± 0.07 #	3.84 ± 0.05 †	4.01 ± 0.07	4.065	0.019	0.060	3.65 ± 0.07 ∞	3.84 ± 0.04 ∞	4.10 ± 0.07 ∞	7.267	0.001	0.103
Sit and reach (cm)	0.62 ± 1.37	3.39 ± 0.95	4.11 ± 1.38	1.819	0.166	0.028	4.40 ± 1.65	3.08 ± 0.96	0.93 ± 1.55	1.004	0.369	0.016
Game Performance												
PIR/game	2.72 ± 0.51	1.88 ± 0.35	1.92 ± 0.51	0.981	0.378	0.015	2.19 ± 0.61	2.29 ± 0.36	1.64 ± 0.58	0.486	0.616	0.008
PIR/min	0.16 ± 0.03	0.09 ± 0.02	0.12 ± 0.03	1.917	0.151	0.029	0.12 ± 0.04	0.13 ± 0.02	0.08 ± 0.04	0.582	0.560	0.009
Points/game	4.15 ± 0.50	3.81 ± 0.35	3.43 ± 0.50	0.478	0.621	0.007	3.81 ± 0.60	3.96 ± 0.35	3.47 ± 0.57	0.292	0.747	0.005
Points/min	0.26 ± 0.03	0.24 ± 0.02	0.24 ± 0.03	0.339	0.713	0.005	0.22 ± 0.03	0.26 ± 0.02	0.24 ± 0.03	0.503	0.606	0.008
Rebounds	2.80 ± 0.26	2.55 ± 0.18	2.65 ± 0.27	0.307	0.736	0.005	2.62 ± 0.32	2.63 ± 0.18	2.68 ± 0.29	0.007	0.993	0.000
Game time (m)	15.37 ± 0.77	14.75 ± 0.53	13.87 ± 0.77	0.888	0.414	0.014	15.86 ± 0.92	14.51 ± 0.54	13.85 ± 0.87	1.037	0.358	0.016

Key: * Significant difference between LFFM and RFFM groups, $p < 0.05$. # Significant difference between LFFM and HFFM groups, $p < 0.05$. † Significant difference between RFFM and HFFM groups, $p < 0.05$. ∞ Significant difference between all groups, $p < 0.05$. [a] Covariate appearing in the model is evaluated at the following value: YAPHV = 1.642 years. BFI = body fat index; BMI = body mass index; CA = chronological age; CMJ = countermovement jump; CMJ-S = countermovement jump with arms swing; FFM = fat-free mass; HBF = higher body fat; LBF = low body fat; MBT = medicine ball throw; PIR = performance index rating; RBF = regular body fat; SUM HG = sum of right and left handgrip; SJ = squat jump; TT = T-test; V20-m = 20 m speed test; YAPHV = years from age at peak height velocity; %BF = percent body fat; LFFM = lower FFM; RFFM = regular FFM; HFFM = higher FFM.

In male players, there were significant differences between BF% groups in the 20 m speed test (p = 0.010, η_P^2 = 0.056), T-test (p = 0.015, η_P^2 = 0.050), CMJ height ($p \leq 0.001$, η_P^2 = 0.092) and relative power (p = 0.004, η_P^2 = 0.067), CMJ-S height ($p \leq 0.001$, η_P^2 = 0.102) and relative power (p = 0.003, η_P^2 = 0.068), PIR/game (p = 0.002, η_P^2 = 0.075) and PIR/min (p = 0.003, η_P^2 = 0.068), points/game (p = 0.017, η_P^2 = 0.049) and points/min (p = 0.025, η_P^2 = 0.044), and minutes played per game (p = 0.020, η_P^2 = 0.047). In addition, significant differences were observed between FFM groups in the 20 m speed test (p = 0.028, η_P^2 = 0.043), T-test (p = 0.001, η_P^2 = 0.043), SUM HG (p = 0.001, η_P^2 = 0.064), MBT (p = 0.049, η_P^2 = 0.037), and rebounds (p = 0.001, η_P^2 = 0.077).

In female players, significant differences were found between BF% groups in MBT (p = 0.019, η_P^2 = 0.060). There were no significant differences between BF% groups in performance-related variables. In addition, there were significant differences between FFM groups in CMJ-S height (p = 0.009, η_P^2 = 0.072) and relative power (p = 0.007, η_P^2 = 0.076), and MBT ($p < 0.001$, η_P^2 = 0.271). There were no significant differences between FFM groups in performance-related variables.

5. Discussion

The purpose of this study was to determine the relationship between BC and physical and performance-related variables, particularly the effect of BF% and FFM of male and female U-14 basketball players on physical tests and game performance indicators after removing the maturity effect. Our results indicate that BC has an impact on physical tests and game performance in male and female U-14 basketball players.

Morphological descriptive statistics (see Table 2) showed that male players were heavier, had more FFM and less BF%, and had a lower BF index than female players. These results align with previous research that pointed out that males have greater BM and FFM, and less BF content compared to their female peers [3,19]. These higher values of BF% in females are mainly due to biological differences such as evolutionary benefits associated with reproduction, pregnancy, and hormonal differences—such as higher estrogen [3]. It is worth mentioning that the FFM sex-related differences may also be explained by cultural factors, such as less attention given to specific strength training with young female players compared to their male counterparts [37] or women's fear of becoming overly muscular [38].

The literature highlights that body fat has an impact on speed, agility, and anaerobic tests performed with and without a ball [8], and it is considered to be an important factor for basketball individuals [14] and team performance [12]. In fact, in a previous study with adolescent male basketball players, significant differences in BF% were found between players from finalists and lower-ranked teams, with higher values of adiposities for lower-classified players [12]. In the present study, the BF% of male players was positively and significantly correlated with speed and COD speed, and negatively correlated with height and relative power of CMJ and CMJ-S. Regarding jumping ability, significant differences were observed between HBF and other players in jump height and relative power, with HBF players jumping less than LBF (−4.31 cm and −5.02 cm) and RBF (−2.26 cm and −2.92 cm) players in CMJ and CMJ-S, respectively. HBF male players were also significantly slower in the 20 m speed test (−0.14 s and −0.11 s) and in the T-test (−0.38 s and −0.30 s) than LBF and RBF players, respectively. The BF% of female players revealed a significantly positive correlation with SUM HG and the 2 kg MBT test, but a negative relationship with height and relative power of CMJ and CMJ-S. Consistent with the ANCOVA results observed in male players, HBF female players performed significantly lower jump heights (−2.03 cm), had significantly less relative power (−0.43 $W \cdot kg^{-1}$) in CMJ, and were significantly slower in the T-test (+0.33 s) than LBF players. In addition, HBF female players threw the 2 kg medicine ball significantly further than LBF (+27 cm) and RBF (+17 cm) players. Regarding the association between BF% and jumping ability, our results are consistent with the findings of previous research, in which the BF% is negatively correlated with players´ jump height in male youth [8] and professional [39] basketball. It is reasonable to suppose that higher adiposity affects players' running and jumping abilities, which, in turn, may have a negative impact on game performance in basketball [25,39].

Regarding the basketball performance of male players, BF% showed a small negative correlation with PIR/game, PIR/min, points/game, and minutes played, where LBF players showed higher values of PIR/game (+2.45), PIR/min (+0.17), points/game (+1.60), points/min (+0.19), and minutes played per game (+2.31 min) than their HBF peers. It should be noted that no differences in height or FFM were observed between the BF% groups, meaning that the differences in players' game performance were mainly due to differences in the athletes' body fat. Contrary to these findings, in female players, no correlations have been identified between BF% and performance-related variables, as well as no differences were found between BF% groups.

Regarding the relationship between FFM and jumping ability, our study did not confirm any significant correlations between FFM and jump height and relative power in male players. On the contrary, in female players, FFM and BM were negatively correlated with both jump height and relative power. There were significant differences between FFM groups in CMJ-S height and relative power. HFFM female players jumped significantly lower and demonstrated less relative power than the LFFM and RFFM female players. To understand these results, we need to consider other factors, such as the age and height of the athletes and their years of experience. The FFM male groups did not show differences in fat mass, but the athletes who had the highest FFM values were also the tallest and, at the same time, the youngest (decimal age). Probably, these athletes had fewer years of basketball training and were less efficient in their jumping skills, compared to the other FFM groups' players. This detail can weigh on the result of their specific performance, nullifying the difference between groups. On the other hand, female athletes did not show differences in height between FFM groups, but showed %BF and age differences, with the youngest players exhibiting more than 11 kg of FFM. The explanation for the female results did not seem to be the same when the groups were compared. Besides, the LFFM group presented less FFM than the HFFM one and were older than the other players, which could mean more experienced in the structured activities of basketball training, and as it was noted for boys, this can be reflected in a better mastery of the jumping technique. However, RFFM players had less FFM and %BF than HFFM players. As %BF was not a differentiating variable of the young female performance, we would say that probably the fewer years of experience, but also the large increase in FFM of these athletes, may not be of great help for the specific jumping performance. It is interesting to note that, in both sexes, the increase in FFM (above a certain value) ceases to be functional for athletes' jumping ability, as well as for speed and COD ability.

According to the literature, it seems that BC influences the speed and COD ability [25], which are considered crucial attributes for basketball performance in both adults [7,40] and youth teams [12,31]. A previous study with young basketball players found that U-12 overweight players had worse performance in running (sprint and endurance) than their leaner counterparts [25]. Although in this study, conducted with male players, no significant correlation was observed between FFM and speed and COD tests, there were significant differences in sprint and COD between FFM groups (see ANCOVA results in Table 4). The results of the 20 m speed test showed that HFFM players were 0.14 s slower than RFFM and LFFM players. The T-test results highlighted the same tendency—the HFFM players were significantly slower than RFFM (+0.55 s) and LFFM (+0.52 s) players. On the contrary, in female players, there was no correlation between FFM and the speed test, but a small positive correlation has been observed between FFM and the T-test. Despite this, no significant differences were found between FFM groups in the T-test results, although HFFM female players were 0.13 and 0.16 s slower than LFFM and RFFM players, respectively.

In the present study, body mass and FFM were positively correlated with SUM HG and MBT, in both sexes. Supposedly, players with more muscle mass have more handgrip strength, and therefore, they can throw the medicine ball further. Previous studies with young Portuguese soccer players showed a positive correlation between FFM and upper body strength [41,42]. It is worth mentioning that the only performance-related variable correlated with FFM was the number of rebounds per game in male players. FFM is an important attribute in elite basketball, particularly in game situations where players must use body contact to create space and fight for a better position to gain possession of the ball (for instance, in rebounding situations) [13]. It is expectable that heavier players, with more FFM and upper body strength, use their body mass and strength to move around smaller players under the basket and, consequently, win more rebounds, which is expressed in a higher PIR per game than their less physically developed peers [13]. Consistent with this previous information, HFFM male players captured significantly more rebounds per game than RFFM (+1.0) and LFFM (+1.83) players. The contribution of growth and maturation to anthropometric characteristics, functional capacity in youth [43], and adolescent basketball players' performance is well-documented in the literature [12–14,43]. Several researchers reported that taller, stronger, faster, and more powerful players were able to gain more rebounds, withstood contact better, scored more points, and stole more balls, which contributed to their higher PIR values [12–14,43]. Since in the present study biological maturation was statistically controlled to avoid its confounding effect, it can be expected that differences between FFM groups in physical fitness, and consequently in player performance-related variables, would tend to disappear or, at least, would be significantly reduced. Our results showed that, in both sexes, there were no significant differences between FFM groups in all performance-related variables (except for rebounds per game in male players). This means that the differences observed in players´ performance can be mainly explained by the differences in BF% and not by the differences in FFM when the maturity effect is removed.

In summary, the findings of this study pointed out that: (i) male players were heavier, had more fat-free mass, and had lower values of BF% and BF index than female players; (ii) in both sexes, BM and FFM were positively correlated with upper body strength (HG and MBT); (iii) in both sexes, BM and BF% were negatively correlated with height and relative power of CMJ and CMJ-S—players with less BF% jumped higher and demonstrated higher relative power than players with more BF%, and (iv) male players with a lower BF% had better game performances (i.e., achieved higher values in all performance-related variables, except for rebounds) than players with a higher BF%.

Our results confirm that BC is related to physical and basketball performance, but further research is needed for a better understanding of this relationship. Further research should help to understand from which FFM cutoff value athletes lose functionality in terms of jumping ability, speed, and COD ability. This study did not consider the impact of BC on more specific game actions. The more specific indicators of players' in-game participation, such as turnovers, steals, and offensive and defensive rebounds, can be differently influenced by the body composition of young basketballers. Besides the age-related effects, young players' practice experience and involvement in structured training programs should also be considered in future studies. The effect of BC on the performance of specific basketball skills, such as dribbling, passing, and shooting, as well as its relationship with the players' game knowledge, may also provide some important clues for a better understanding of basketball talent.

6. Practical Applications

The results of the present study highlighted the following:

- The control of body fat in young players may be an important factor in improving individual and team performances. However, above all, the control of body fat may be a relevant aspect to promote the normal and adapted development of the young athlete.
- BC should be considered in the basketball talent identification and development programs.
- Coaches should focus on special intervention exercises and nutrition programs targeting optimal body mass, especially in young basketball players, where excessive body mass negatively affects running and jumping performances.

- Females carry greater BF than males due to biological differences. These differences must be considered by practitioners working with female basketball players, from both performance (e.g., speed, power training) and health-related (e.g., manipulating training loads to reduce the risk of injury) perspectives.

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