Original article

Relationship of body mass status with running and jumping performances in young basketball players

Pantelis Theodoros Nikolaidis[1]
Abbas Asadi[2]
Eduardo J.A.M. Santos[3]
Julio Calleja-González[4]
Johnny Padulo[5]
Hamdi Chtourou[6]
Erika Zemkova[7]

1 Department of Physical and Cultural Education, Hellenic Army Academy, Nikaia, Greece
2 Department of Physical Education and Sport Sciences, Payame Noor University, Tehran, Iran
3 Universidad do Porto, Faculty of Sport, Porto, Portugal
4 Universidad del País Vasco, Donostia-San Sebastian, Spain
5 University eCampus, Novedrate, Italy
6 Tunisian Research Laboratory “Sport Performance Optimisation”, National Center of Medicine and Science in Sports, Tunis, Tunisia
7 Faculty of Physical Education and Sports, Comenius University, Bratislava, Slovakia

Corresponding author:
Pantelis Theodoros Nikolaidis
Department of Physical and Cultural Education, Hellenic Army Academy
Thermopylon 7
18450 Nikaia, Greece
E-mail: pademil@hotmail.com

Summary

Purpose: **the main purpose of this study was to examine the relationship of body mass (BM) status with running and jumping performances in young male basketball players.**
Methods: **basketball players (n=72, age 12.9±2.8 yrs), who were grouped into U-12 (9-12 yrs), U-15 (12-15 yrs) and U-18 (15-18 yrs), performed a battery of anthropometric, running and jumping tests. We examined differences among age groups, and between normal weight and overweight players.**
Results: **the results indicated significant and large differences among age groups in BM, height, body mass index (BMI), fat mass (FM), fat-free mass, speed, endurance, standing long jump, countermovement jump (CMJ), mean power in 30 s jumping test (Pmean) ($p<0.001$, $\eta^2\geq0.23$) with older players presenting higher values. Within each age group, overweight players had higher BM, BMI, body fat percentage and FM ($p<0.05$) than their normal weight counterparts. Overweight players had worst performance in running (sprint and endurance) and jumping (CMJ and Pmean) in U-12, and worst endurance in U-18 ($p<0.05$, $|d|\geq0.82$) than normal-weight players, whereas there was no difference in U-15.**
Conclusions: **it was concluded that the relationship of BMI with running and jumping performances varied according to age. Based on these findings, trainers and coaches should focus on special intervention exercise and nutrition programs targeting optimal body mass especially in young basketball players, where the excess of body mass seemed to have the most detrimental effect on running and jumping performances.**

KEY WORDS: adiposity, age, overweight, performances, physical exercise, team sport.

Introduction

The research on the physical determinants of basketball performance from a physiological perspective has focused on profiling of physical fitness characteristics of elite players[1-6]. It has been suggested that elite basketball players should have high stature and increased anaerobic power[7, 8]. Moreover, the achievement of an optimal body mass (BM) is a main concern in daily basketball practice. Body mass index (BMI) is an easily-administered and inexpensive tool to monitor BM status. Although it is commonly used in a health-setting to classify humans as underweight, normal weight, overweight and obese[9], its application in sport populations has been questioned, because it is associated with fat mass, as well as with fat-free mass[10]. Independently from this limitation, it still can evaluate athlete’s BM for a given stature, and thus, contribute to BM control. However, BMI is often overlooked in studies in sport populations and there are many studies in basketball players which present data on height and BM, but not on BMI[1, 11-15].
Although basketball is a widely practiced sport worldwide, to the best of our knowledge no study has ever been conducted to investigate the effect of elevated BMI on running and jumping performances in young male basketball players. There is evidence from re-

search conducted chiefly on general populations that BMI is associated with reduced physical fitness[16-20] and the same has been shown recently in soccer, volleyball and handball[21-23]. The comparison among groups with different BMI in these studies has revealed that the groups with lower or normal BMI perform better in physical fitness tests than overweight/obese (i.e., higher BMI). While such findings would be attributed to the association of BMI with fat mass, we would not expect the same magnitude of association between BMI and physical fitness in the case of sport populations, in which there is an increased fat-free mass.

Therefore, the main objective of this study was to examine the relationship of BMI with running and jumping performances of male basketball players, with an emphasis on the characteristics which are linked with sport excellence (e.g., sprint and vertical jump)[8]. We hypothesized that a higher BMI would have negative effects for performance in the selected tests. Also, we explored whether this relationship was age-dependent, i.e., whether a higher BMI had the same implications for test performances in different age groups of young players. Since recent research has shown age-related differences in physical and physiological characteristics in young players with the older presenting better characteristics[24], the relationship of BMI with running and jumping performances might also be influenced by age. It might be expected to find that elevated BMI was more negative for test performances in the very young players in this cohort compared to the older players due to the lower fat-free mass in the former one[24].

Materials and methods

We used a cross-sectional study design to examine the relationship of BM status with running and jumping performances in young basketball players of different age groups. To this end, normal-weight and overweight were measured and compared. Running and jumping performances were designated as dependent variables. BM status (normal-weight or overweight) was designated as the independent variable. The study protocol was performed in accordance with the ethical standards from the Declaration of Helsinki in 2008 and approved by the local Institutional Review Board according to the guidelines of Muscles, Ligaments and Tendons Journal[25]. Informed written consent from the parents and assent from the players were obtained.

Seventy-two male basketball players, who were members of the academy of a Greek first league club, volunteered to participate in this study. The sample included three groups, under 12 yrs (9-12 yrs, U-12, n=32), under 15 yrs (12-15 yrs, U-15, n=23) and under 18 yrs (n=17, U-18) (Tab. 1). Players were excluded if they had a chronic pediatric disease, were taking medications or had an orthopedic condition that would limit their ability to perform tests. All participants had at least three years of playing experience and competed to one game per week. In addition, U-12, U-15 and U-18 participated to three, four and five training sessions per week, respectively.

Testing procedures were performed in the end of the competitive period of the season 2012-2013. The participants were familiar with testing procedures, because the present physical fitness battery was routinely administered to the members of this academy in the past. Each participant took part in two testing sessions during a weekend separated by 24 h rest. The first session included anthropometric, body composition and jumping measures, whereas running tests were administered in the second session. Both sessions took place in the team's indoor court under standard environmental conditions (temperature 22-24°C and humidity 50-54%) between 9 am and 11 am. Except 30 s Bosco test and 20 m endurance shuttle run test which were performed once, two trials were performed for each test and the best score was recorded. The intra-class correlations for these tests ranged from 0.91 to 0.99[26-28].

(a) Anthropometry and body composition. Height, body mass and skinfolds were measured with subjects barefoot and in minimal clothing. An electronic weight scale (HD-351 Tanita, Illinois, USA) was employed for BM measurement (at the nearest 0.1 kg), a portable stadiometer (SECA, Leicester, UK) for height in the Frankfurt plane (0.001 m) and a caliper (Harpenden, West Sussex, UK) for skinfolds (0.5 mm). Body mass index (BMI) was calculated as the quotient of BM (kg) to height squared (m^2), and body fat percentage (BF) was estimated from the sum of 10 skinfolds (cheek, wattle, chest I, triceps, subscapular, abdominal, chest II, suprailiac, thigh and calf; $BF = -41.32 + 12.59 \times \log_e x$, where x the sum of 10 skinfolds)[29]. A two-component model of body composition was used to divide body into fat mass (FM), calculated as FM = BM × BF, and fat-free mass (FFM), estimated as FFM = BM - FM. Chronological age for each participant was calculated using a table of decimals of year[30]. Peak height velocity (PHV), which reflects the maximum velocity in growth of height, was used as an indicator of biological maturity. Age at PHV (APHV) was predicted by equation taking into account sex, date of birth, date of measurement, height, sitting height and body mass[31], and difference (ΔAPHV) between chronological age and age at PHV was used as a measure of biological age.

(b) Standing long jump (SLJ), countermovement vertical jump (CMJ) and 30 s Bosco test. The SLJ was performed with feet slightly apart and arm movements (swing) were allowed for support during the take-off[32]. Trials were evaluated only when participants landed properly on their feet without falling back. The distance between the toes at start and the heels at landing was used as a testing criterion. Participants were also tested in CMJ with arm swinging[33]. Jumping ability is one of the most important factors associated with success in basketball, and thus CMJ is commonly used in the assessment of basketball players' physical fitness[8]. In addition, CMJ performance is characterized by a very low variability between tests (coefficient of variation of 3.0%)[34]. Participants started in a standing position with both feet together and were asked to jump as high as possible with a rapid countermovement. The depth of the countermovement was self-selected and participants were asked to land as close as possible to their point of take-off[35]. Flight time was used to calculate the change in the height of the body's centre of gravity[36]. Height of jump was estimated using the Opto-jump (Microgate Engineering, Bolzano, Italy). Bosco test was conducted with the same equipment used for the CMJ test. Players were instructed to jump continuously as high as possible, while trying to stay on the ground as little as possible for 30 s[37]. Mean power was recorded in W.kg^{-1}.

(c) 20 m sprint and 20 m shuttle run endurance test (SRT). 20 m sprint was timed using a photocell system (Brower Timing Systems, Utah, USA)[38]. 20 m sprint performance has been shown to significantly correlate with playing time in NCAA Division I players[39]. The use of three pairs of photocells, set at 0, 10 and 20 m allowed to record performance of split 0-10 m and split 10-20 m, in addition to 20 m sprint. The photocells were placed at the belt height in order the legs not to break the light beam according to manufacturer's guidelines and players started their attempts from a standing position 0.5 m behind the first pair of photocells. Endurance performance was tested with the widely used 20 m SRT[40]. Briefly, players performed an incremental running test in an indoor court between two lines 20 m apart. Initial speed was set at 8.5 km.h^{-1} and increased every minute by 0.5 km.h^{-1} until exhaustion. During the late stages of the test, participants were cheered vigorously to make maximal effort. In addition, they had been instructed to adhere strictly to the speed that was dictated by audio signals. Maximal heart rate (HR_{max}) was defined as the highest value attained during the test. Heart rate was recorded continuously during the test by Team2 Pro (Polar Electro Oy, Kempele, Finland).

Statistical analyses were performed using IBM SPSS v.20.0 (SPSS, Chicago, USA). Data were expressed as mean and standard deviations of the mean (*SD*). International age-specific cut-off points of BMI[41] were employed to classify players into normal, overweight or obese. These cut-off points correspond to the adult values suggested by the World Health Organization [normal (≤25 kg.m^{-2}), overweight (25-30 kg.m^{-2}) or obese (>30 kg.m^{-2})][9]. Due to the small number of obese (two in U-12, one in U-15 and one in U-18), these players were incorporated in the overweight group. Chi-square examined differences in the prevalence of overweight among age groups. All the variables after being tested for normality satisfied the equality of variances according to Kolmogorov-Smirnov test for n>50. Only the best score of each test was included in the data analysis and the parametric analysis techniques were used. One-way analysis of variance (ANOVA) with a subsequent Bonferroni *post-hoc* test (if differences between groups were revealed) was used to examine differences among age groups (U-12, U-15 and U-18). To interpret effect sizes (ES) for statistical differences in the ANOVA we used eta square classified as small ($0.01<\eta^2\leq0.06$), medium ($0.06<\eta^2\leq0.14$) and large ($\eta^2>0.14$)[42]. Student independent t-test was employed to test differences in running and jumping performances between normal and overweight participants for each age group. ES for statistical differences were determined using the following criteria: *ES*≤0.2, trivial; 0.2<*ES*≤0.6, small; 0.6<*ES*≤1.2, moderate; 1.2<*ES*≤2.0, large; and *ES*>2.0, very large[43]. The association of BMI with running and jumping performances was examined using Pearson's product moment correlation coefficient (*r*). Magnitude of correlation coefficients were considered as trivial (*r*≤0.1), small (0.1<r≤0.3) moderate (0.3<*r*≤0.5), large (0.5<*r*≤0.7), very large (0.7<*r*≤0.9) and nearly perfect (*r*>0.9) and perfect (*r*=1.0)[42]. The level of significance was set at $\alpha=0.05$.

Results

The distribution of normal-weight and overweight basketball players by age group is presented in Table 1. Chi-square analysis did not show any significant difference in the prevalence of overweight among age groups [$\chi^2(2)=2.96$, p=0.228]. The differences in physical characteristics, running and jumping performances by age group are shown in Table 2 and Table 3. The age groups differed for BM, height, BMI, FM, FFM, speed, endurance, SLJ, CMJ and P_{mean} ($p<0.001$, $\eta^2>0.23$) with older players presenting higher values. A large effect of age was observed for all the aforementioned parameters.

The differences in physical characteristics, running and jumping performances by BM status are presented in Table 4 and 5. Within each age group, overweight players had higher BM, BMI, body fat percentage, FM (p<0.05). Compared with normal-weight, overweight players had worst performance in running [20 m sprint +0.32 s (0.04;0.60), mean difference (95% confidence intervals), Cohen's d=0.90 and endurance -1:20 min: s (-2:36;-0:04), d=-0.82)] and jumping [CMJ -7.3 cm (-11.0;-3.7), d=-1.67 and P_{mean} -6.3 W.kg^{-1} (-10.1;-2.6), d=-1.44] in U-12; and worst endurance in U-18 [-2:16 min: s (-3:57;-0:34), d=-1.39], whereas there was no difference in U-15. HR_{max} in the end of 20 m SRT was higher than 95% of the age-predicted HR_{max}, which was used as a criterion to evaluate whether there was maximal effort.

In the total sample, we observed moderate and negative correlations of BMI with sprint, and positive correlations with jumping tests (low to moderate) (Tab. 6). In U-12, we noticed small and negative correlations of BMI with jumping tests. In U-15, there was no significant correlation. In U-18, we observed large and negative correlation of BMI with endurance. In total, BMI

Table 1. Classification of basketball players by body mass status.

	Total (n=72)		U-12 (n=32)		U-15 (n=23)		U-18 (n=17)	
	Normal-weight	Overweight	Normal-weight	Overweight	Normal-weight	Overweight	Normal-weight	Overweight
n	45	27	23	9	14	9	8	9
%	62.5	37.5	71.9	28.1	60.9	39.1	47.1	52.9

Table 2. Physical characteristics and body composition of basketball players.

	Total (n = 72)	U-12 (n = 32)	U-15 (n = 23)	U-18 (n = 17)	Comparison
Age (yr)	12.9±2.8	10.3±1.2ǁ,¶	13.5±0.7§,¶	16.9±0.6§,ǁ	$F_{2,69}$=262.0, p<0.001, η^2=0.88
ΔAPHV (yrs)	-0.4±2.3	-2.6±0.6ǁ,¶	-0.3±0.8§,¶	2.7±0.9§,ǁ	$F_{2,63}$=251.7, p<0.001, η^2=0.89
BM (kg)	56.4±19.1	40.0±8.4ǁ,¶	61.5±11.3§,¶	80.3±11.0§,ǁ	$F_{2,69}$=94.7, p<0.001, η^2=0.73
Height (cm)	161.6±17.4	145.8±8.7ǁ,¶	168.1±10.0§,¶	182.4±6.2§,ǁ	$F_{2,69}$=109.5, p<0.001, η^2=0.76
BMI (kg·m^{-2})	20.9±3.5	18.7±2.5ǁ,¶	21.7±2.5§,¶	24.2±3.4§,ǁ	$F_{2,69}$=24.2.0, p<0.001, η^2=0.41
BF (%)	17.7±4.1	17.6±4.7	18.6±2.8	16.7±4.3	$F_{2,69}$=1.0, p=0.358, η^2=0.03
FM (kg)	10.2±4.5	7.3±3.2ǁ,¶	11.5±3.2§	13.7±4.9§	$F_{2,69}$=19.7, p<0.001, η^2=0.36
FFM (kg)	46.2±15.4	32.7±5.7ǁ,¶	50.0±8.7§,¶	66.6±7.3§,ǁ	$F_{2,69}$=130.2, p<0.001, η^2=0.79

Data are mean±SD. ΔAPHV=difference from age at peak height velocity, BM=body mass, BMI=body mass index, BF=body fat, FM=fat mass, FFM=fat-free mass. The symbols §,ǁ and ¶ denote significant differences with U-12, U-15 and U-18, respectively, according to Bonferroni test.

Table 3. Running and jumping performances of basketball players.

	Total (n = 72)	U-12 (n = 32)	U-15 (n = 23)	U-18 (n = 17)	Comparison
Sprint 20 m (s)	3.75±0.43	4.07±0.37ǁ,¶	3.67±0.27§,¶	3.27±0.11§,ǁ	$F_{2,69}$=41.7, p<0.001, η^2=0.55
Split 0-10 m (s)	2.14±0.21	2.28±0.19ǁ,¶	2.10±0.13§,¶	1.91±0.06§,ǁ	$F_{2,69}$=36.3, p<0.001, η^2=0.51
Split 10-20 m (s)	1.62±0.23	1.79±0.19ǁ,¶	1.57±0.15§,¶	1.36±0.06§,ǁ	$F_{2,69}$=42.2, p<0.001, η^2=0.55
Endurance (min:s)	6:21±2:16	5:01±1:40ǁ,¶	6:29±1:44§,¶	8:42±1:58§,ǁ	$F_{2,69}$=24.2, p<0.001, η^2=0.41
SLJ (m)	1.94±0.37	1.65±0.21ǁ,¶	2.01±0.24§,¶	2.38±0.26§,ǁ	$F_{2,69}$=57.8, p<0.001, η^2=0.63
CMJ (cm)	29.9±8.5	23.9±5.6ǁ,¶	31.8±6.1§,¶	38.6±7.0§,ǁ	$F_{2,69}$=33.5, p<0.001, η^2=0.49
Bosco (W.kg^{-1})	22.7±8.3	18.1±5.5¶	21.9±4.9¶	32.7±8.0§,ǁ	$F_{2,69}$=33.5, p<0.001, η^2=0.49

Data are mean±SD. SLJ=standing long jump, CMJ=countermovement vertical jump. The symbols §,ǁ and ¶ denote significant differences with U-12, U-15 and U-18, respectively, according to Bonferroni test.

Table 4. Physical characteristics and body composition of basketball players by body mass status.

	Total (n=72)		U-12 (n=32)		U-15 (n=23)		U-18 (n=17)	
	Normal-weight (n=,45)	Overweight (n=27)	Normal-weight (n=23)	Overweight (n=9)	Normal-weight (n=14)	Overweight (n=9)	Normal-weight (n=8)	Overweight (n=9)
Age (yrs)	12.6±2.7	13.4±2.9	10.5±1.3	10.0±1.2	13.5±0.7	13.4±0.7	17.0±0.7	16.8±0.6
ΔAPHV (yrs)	-0.9±2.1	0.4±2.3*	-2.7±0.7	-2.5±0.6	-0.6±0.8	0.1±0.7*	2.6±1.1	2.8±0.7
BM (kg)	48.7±15.5	69.2±17.9‡	36.6±7.1	48.4±4.8‡	54.8±6.7	72.0±8.6‡	72.7±6.9	87.1±9.6†
Height (cm)	158.0±17.5	167.5±15.8*	144.6±9.1	148.8±7.1	165.4±10.2	172.4±8.5	183.6±4.6	181.3±7.4
BMI (kg·m^{-2})	19.0±2.2	24.2±2.8‡	17.4±1.5	21.9±1.3‡	20.0±0.9	24.2±1.9‡	21.6±1.7	26.6±2.7‡
BF (%)	15.6±3.2	21.2±2.9‡	15.2±3.0	23.6±1.6‡	17.1±2.2	20.8±2.2‡	13.9±4.2	19.2±2.7†
FM (kg)	7.6±2.9	14.4±3.4‡	5.7±1.9	11.4±1.4‡	9.3±1.3	14.9±2.1‡	10.2±3.4	16.9±3.7†
FFM (kg)	41.1±13.2	54.8±15.1‡	31.0±5.5	37.0±3.7†	45.4±6.1	57.1±7.3‡	62.5±5.8	70.3±6.7*

Data are mean±SD. ΔAPHV=difference from age at peak height velocity, BM=body mass, BMI=body mass index, BF=body fat, FM=fat mass, FFM=fat-free mass. The symbols *, † and ‡ denote significance level of p<0.05, p<0.01 and p<0.001, respectively, for differences between normal and overweight participants using independent student t-test.

Table 5. Running and jumping performances of basketball players by body mass status.

	Total (n=72)		U-12 (n=32)		U-15 (n=23)		U-18 (n=17)	
	Normal-weight (n=45)	Overweight (n=27)	Normal-weight (n=23)	Overweight (n=9)	Normal-weight (n=14)	Overweight (n=9)	Normal-weight (n=8)	Overweight (n=9)
Sprint 20 m (s)	3.75±0.40	3.76±0.49	3.98±0.33	4.30±0.38*	3.65±0.31	3.69±0.22	3.24±0.09	3.30±0.12
Split 0-10 m (s)	2.13±0.20	2.14±0.23	2.24±0.18	2.39±0.17*	2.09±0.14	2.12±0.11	1.91±0.07	1.91±0.07
Split 10-20 m (s)	1.61±0.21	1.62±0.27	1.74±0.16	1.91±0.23*	1.56±0.17	1.57±0.12	1.33±0.04	1.39±0.07
Endurance (min:s)	6:40±2:20	5:51±2:04	5:24±1:28	4:03±1:48*	6:54±2:01	5:51±0:56	9:54±1:37	7:38±1:38*
SLJ (m)	1.93±0.37	1.95±0.38	1.69±0.20	1.54±0.20	2.00±0.26	2.03±0.21	2.48±0.25	2.29±0.25
CMJ (cm)	30.5±7.6	28.9±9.8	26.0±4.7	18.7±4.0‡	32.6±7.0	30.7±4.4	40.0±4.2	37.3±8.9
Bosco ($W.kg^{-1}$)	23.4±8.4	21.6±8.1	19.9±5.0	13.5±3.7†	21.8±5.1	22.0±4.7	36.6±8.4	29.2±6.1

Data are mean±SD. SLJ=standing long jump, CMJ=countermovement vertical jump. The symbols *, † and ‡ denote significance level of p<0.05, p<0.01 and p<0.001, respectively, for differences between normal and overweight participants using independent student t-test.

Table 6. Correlation (Pearson coefficient r) of BMI and BF with running and jumping performances of basketball players by age group.

	Total (n=72)		U-12 (n=32)		U-15 (n=23)		U-18 (n=17)	
	BMI	BF	BMI	BF	BMI	BF	BMI	BF
Sprint 20 m (s)	-0.35†	0.26*	0.30	0.30	0.15	0.49*	0.45	0.50*
Split 0-10 m (s)	-0.33†	0.27*	0.32	0.30	0.18	0.49*	0.29	0.39
Split 10-20 m (s)	-0.36†	0.25*	0.28	0.30	0.11	0.44*	0.50*	0.46
Endurance (min:s)	0.18	-0.42‡	-0.25	-0.41*	-0.32	-0.38	-0.64†	-0.75‡
SLJ (m)	0.42‡	-0.25*	-0.16	-0.20	-0.10	-0.40	-0.31	-0.57*
CMJ (cm)	0.25*	-0.42‡	-0.25*	-0.61‡	-0.25	-0.59†	-0.28	-0.49*
Bosco ($W.kg^{-1}$)	0.24*	-0.39‡	-0.25*	-0.53†	-0.14	-0.17	-0.34	-0.52*

Data are mean±SD. BMI=body mass index, BF=body fat, SLJ=standing long jump, CMJ=countermovement vertical jump. The symbols *, † and ‡ denote significance level of p<0.05, p<0.01 and p<0.001, respectively.

was correlated with BF (r=0.56), FM (r=0.94) and FFM (r=0.82). The respective correlations in U-12 were r=0.89, r=0.94 and r=0.74; in U-15 r=0.67, r=0.92 and r=0.70; and in U-18 r=0.77, r=0.87 and r=0.72 (p<0.001 for all the aforementioned correlations).

Discussion

The main finding of the present study was that there was an association of BM status with running and jumping performances in young basketball players. In U-12, a high BMI indicated low running and jumping performances, whereas in U-18 there was a large effect of BM status on endurance. These findings were in agreement with the negative correlation of BMI with running and jumping performances. We interpreted this finding to indicate that the excess of body mass had a negative effect on running and jumping performances.

Although the relationship between BMI and repeated jumping performance (30 s Bosco test) was not studied previously in basketball, there were indications for a negative effect of BMI on mean power based on previous research on anaerobic power assessed by the Wingate anaerobic test in male soccer[44], female volleyball players[22] and by Bosco test in male handball players[23]. Taking into account the significant correlation between Bosco test and the percentage of fast-twitch muscle fibers[45], a high performance in this test might have implications not only on players' ability to repeatedly perform jumps, but also on their ability to accelerate and develop maximum speed. Consequently, it would not be a surprise to observe a high level of sprinting performance in those who performed well in the jumping tests. On the other hand, our findings indicated that excess BM is related with decreased sprinting and jumping ability in the youngest group. These performances represent a crucial part of performance in basketball and should be considered as an integral part of any training program in this sport. Moreover, since sprint ability is also related with agility performance[46], it is reasonable to assume that excess BM might also affect agility.

The normal-weight players obtained higher values in CMJ when compared to the overweight ones. These differences were observed consistently in the total sample and in each age group, but there was statistical significance only in U-12 group. These outcomes are similar to the data presented in the study of Castro-Piñero et al.[47], where normal-weight children and adolescents had higher performance than their overweight counterparts in the vertical jump test.

We observed more BM-related differences in body composition than in running and jumping performances (Figs. 1, 2). However the differences between normal-weight and overweight players with regard to body composition were not consistent among age groups. For instance, overweight players differed from normal-weight players with regard to BF in U-12 by +8.4% and

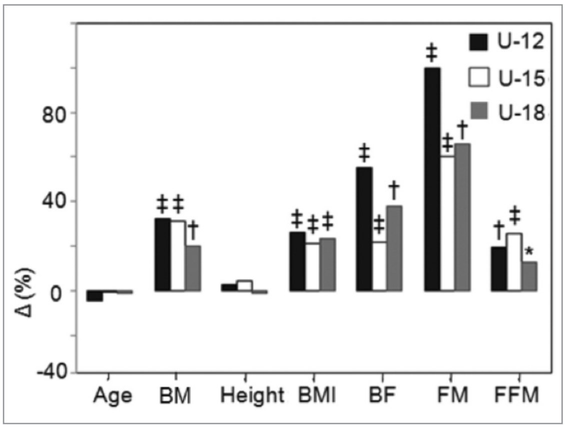

Figure 1. Percentage differences (Δ) between overweight and normal-weight basketball players by age group. BM=body mass, BMI=body mass index, BF=body fat, FM=fat mass, FFM=fat-free mass. The symbols *, † and ‡ denote significance level of p<0.05, p<0.01 and p<0.001, respectively.

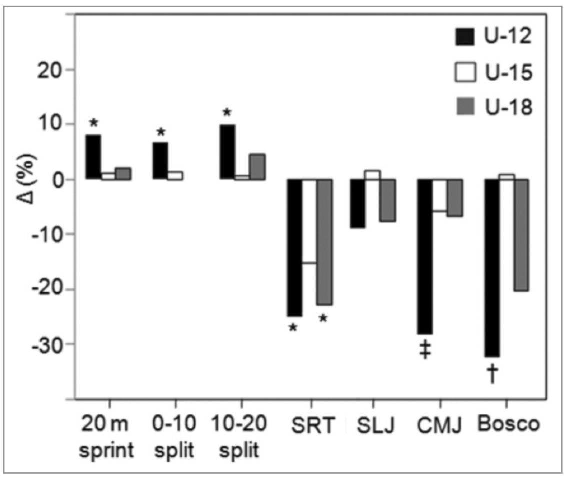

Figure 2. Percentage differences (Δ) between overweight and normal weight basketball players by age group. SRT=shuttle run test, SLJ=standing long jump, CMJ=countermovement vertical jump. The symbols *, † and ‡ denote significance level of p<0.05, p<0.01 and p<0.001, respectively.

in U-15 by +3.7%, and regarding FFM in U-12 by +6.0 kg and in U-15 by +11.7 kg. Nevertheless, the physiological mechanisms behind the above-mentioned associations of BMI with running and jumping performances were not clarified yet. The excess of BF and FM observed in overweight adolescents could explain these differences, because this mass is an extra load to be moved while performing the tests[16]. We found this assumption strengthened by the closer association of BMI with BF and FM in the younger group compared with the older groups. In addition, BMI was more strongly correlated with BF and FM than with FFM. Consequently, it was reasonable to support that BMI exerted a similar effect on running and jumping performances as BF did, but with lower magnitude (Tab. 6). Moreover, it is known that the percentage of BF is negatively correlated with performance time in the running speed and the high intensity shuttle run[48]. This negative correlation is disadvantageous in basketball performance. However, taking into account the BF presented by the athletes of our study in the different age levels we might also state that participation in basketball training contributes to a reduction of BF[49].

The main limitation of this study was its cross-sectional design, which did not allow revealing causal relationships among the parameters under examination. Another limitation was the sample size, which did not allow comparing many BMI groups. However, previous studies that compared more than two BMI groups[16,17,21] have mentioned that the relationship between BMI and most of motor performances follows an inverse "U" pattern rather than to be linear. This can explain partially the lack of statistically important differences between normal-weight and overweight groups, as well as the relatively small correlations between BMI and most of running and jumping performances.

Despite these drawbacks, the findings of the present research have important practical implications in basketball training. Searching the scientific literature, we noticed that previous research has paid no attention to the role of BMI in this sport. Moreover, this is the first study, to our knowledge, to address the question of overweight and its consequences on young basketball players. It seems that an increased BM presents different implications for running and jumping performances among different age groups and this must be taken into account by coaches and trainers. The strength of this study was that the participants were members of the academy of a club competing in the first Greek league. Although the success of Greek clubs in the most important basketball competition in Europe (they won 4 out of 5 Euroleague competitions during 2008-2013) and high performance of the national team (5th out of 87 countries in the FIBA World ranking, FIBA official web site, accessed on January 24, 2014), there is lack of scientific research on physical traits and physiological profile of basketball players in this country. Therefore, the data from this study can also be used as reference of elite young basketball players acting complementarily to the existing literature[1].

Conclusions

In conclusion, running and jumping performances are likely key components of performance in basketball. The findings of this study show that these performances are related to BM status with overweight basketball players (9-12 years) presenting lower scores than their normal-weight counterparts. However, this relationship was not verified for older age groups (12-15 years and 15-18 years) indicating that an excess of BM might have not the same implications for basketball players differing in age.

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