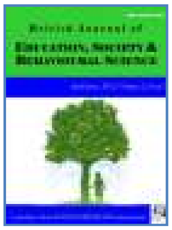

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Does Body Fat Affect Performance Indicators in Youth Soccer?

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Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

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ABSTRACT

Aims: The study aimed to identify the relationship between body parameters and performance factors for different age groups.
Study Design: The researchers recorded the indoor tests (height, weight, body fat, body mass index, and vertical jump) and then they recorded the outdoor tests (sprint, agility, and VO2max). The measurements took place at the beginning of the competitive season. The tests were scheduled under similar conditions of time, light, temperature, and a standardized warm-up.
Methodology: 314 Greek young male players aged 7-17 years old participated in the current study. The portable device called the OptoJump System (Microgate, Bolzano, Italy) was used to measure the performance factors of each player. A weighting scale (BC1000, Tanita, Japan) and a cursor were used to measure the body parameters.
Results: It was found that body fat and then body mass index were the most important predictors of performance factors. Specifically, body fat was the most important predictor of performance

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factors from 10 to 15 years old.
Conclusion: As body fat is a factor that determine the performance of youths it is crucial for the training staff to assess players' body parameters very frequently throughout a season.

Keywords: Anthropometric; body fat; body mass index; performance; relative age; soccer.

1. INTRODUCTION

Soccer is almost the most widely played sport worldwide, which is related to a plethora of physiological, physical, psychological, social, technical, and tactical characteristics [1,2,3]. Thus individual performance is a result of the balanced development and interaction of these characteristics. However, soccer training staff is very frequently more focused on physically stronger players [4] who are more often enrolled in elite clubs and national teams [5,6]. Selection for elite clubs and national teams heighten the differences by providing better expertised coaching staff and training, increased competitive conditions and playing time [7,8,9], and a great development of psychological factors such as the perceived competence, self-efficacy and self-esteem [10,11,12,13] for physically stronger players. Although a great body of research about the advantages of physically matured players has been developed, there are also disadvantages that players face due to anthropometric factors. Players with greater rates of height and body mass index perform better in factors such as vertical jump, speed, and VO2max [14]. On the other hand players' higher rates of weight and body fat affect negatively the performance [15,16], speed and VO2max [17]. But anthropometric factors are not constant predictors of performance. Furthermore, it is not clear which performance factors does body size affect for each age group. Flegal (1999) suggested that this small chronic imbalance between energy intake and energy expenditure that increase weight and body fat is not a constant negative factor [18]. Numerous studies, the majority of which is focused on treating adults, examined the relationship between physical activity and weight [19,20]. The researchers concluded that body fat, body mass, and body mass index reduced in children and adolescents because of physical activity. LeMura and Maziekas (2002) concluded that low exercise intensity, long exercise duration, a combination of aerobic and 8 to 12 repetitions of resistance exercise, intervention of exercise plus behavior modification resulted in the greatest reductions in body fat rates of children [19]. Besides, it is suggested that soccer as a sport activity, prevents or treats overweight and its comorbidities [21]. It has also been found that weight and body fat alter as a result of training, habitual activity and diet, during off-season, conditioning, or even competitive season [16,22,23]. Moreover, soccer players even high leveled tend to have higher depots of body fat than optimal [24,25]. Thus, anthropometric factors are not the only ones that define elite players. In addition factors such as technique, tactics, and coaching strategy play a crucial role for the performance [17]. Researchers hypothesized that anthropometric factors affect player's performance. In the current study the researchers examined the relationship between anthropometric and performance factors for players aged 7-17 years old so as to define which relationships are stronger for each age. Ulterior aim of the study was to identify the relationship between body parameters with performance factors.

2. MATERIALS AND METHODS

2.1 Participants

In the present study 314 Greek young players participated. They were members of Greek soccer teams for the season 2013-2014. The participants' age ranged from 7 to 17 years old (M = 12.36, SD = 2.58). The parents or the guardians of the kids were notified about procedures, requirements, benefits, and risks of the research before giving informed consent as the players were not yet adults. Furthermore, a University Research Ethics Committee granted approval for the study.

2.2 Design

The measurements of the entire study were performed by the same researchers specialized in sport ergophysiology and sport psychology. The researchers informed participants' parents or guardians about the aims and the ethics of the study. Then they arranged the dates of measurement at the beginning of the competitive season and before the first training. The tests were scheduled under similar conditions of time, light, temperature, and a standardized warm-up. Initially, researchers recorded the indoor tests (height, weight, body fat, body mass index, and vertical jump) and then they recorded the outdoor tests (sprint, agility, and VO2max). The breaks between the trials were around 3-5 minutes, especially for the sprint and agility trials.

2.3 Measurementes / Questionnaires

The anthropometric factors that the researchers examined were the height, the weight, the body mass index and the body fat. A weighting scale (BC1000, Tanita, Japan) was used for the evaluation of weight (kg), body mass (kg) and body fat (%). The scale transmitted the results directly to a computer program. A cursor was placed on each participant's head so as to measure their height (cm). The portable device called the OptoJump System (Microgate, Bolzano, Italy) was used to measure the performance factors of each player. The OptoJump System is an optical measurement system consisting of a transmitting and receiving bar, one meter long each bar. Each of these bars contains from 32 to 96 leds, depending on the chosen resolution, in a distance of 2 millimeters from the ground. The transmitting bar's leds communicate continuously with those of the receiving bar. Any interruption in communication between the bars is detected by the system which calculates the duration. Thus it is possible to measure flight and contact times during the performance of a series of jumps with a great accuracy (1/1000 of a second) and in real time. Vertical jump was measured as the higher jump of three countermovement trials with hands on hips. Jumps were separated by rest periods of 5 seconds each. The validity and reliability of this system was recently supported for abilities measurements [26]. Sprint ability was evaluated using 2 pairs of photocells (Microgate, RACETIME 2), placed on the beginning and in the end of the distance. Players aged 7-12 were measured on 10m and 20m sprint while 13-17 years old players' were measured on 10m and 30m sprint. The researchers recorded the better of the two trials for each player. Agility was measured using the Illinois agility run [27,28]. The test started with a player standing with one foot in front of the other at the starting line. On the command "Go", participants sprinted 9m, and turned back to the starting line. Then they swerved in and out of four markers, completing two 9m sprints go and return. Finally to finish the agility test they had to run 9m go and return to the finishing line. The fastest value of two trials was recorded. Time recovery was 3 minutes before each trial. Time was measured with timing gates using photocells (Microgate, RACETIME 2) positioned at the starting and the finishing line. Finally, VO2max was assessed using a 20m continuous progressive track run test [29]. This outdoor test took place on the pitch between two parallel lines of 20m distance that the players had to run back and forth between. A recorded soundtrack indicated with a beep sound when the players have to reach the 20m line. The first stage was set at 8,5 km/h with subsequent increments of 0.5 km/h per 1-min stage. When a player was unable to reach the line before the sound for two times in row the test finished. The last completed stage indicated the maximal aerobic speed which was used to calculate the maximal oxygen uptake.

2.4 Statistical Analysis

All statistical analyses were performed using the SPSS package (v. 17). The techniques that employed were descriptive statistics for all the variables. Then, correlations Pearson r were conducted to define the relationships among the factors. Finally, regression analyses were performed to identify which anthropometric factors predict better the performance ones.

3. RESULTS

Primarily the researchers divided the age groups according to the European standards for age classification of academies from under-8 to under-18 years old. The (Table 1) shows the descriptive statistics of the anthropometric variables that were examined.

Similarly, the following table shows the descriptive statistics of the performance variables that were examined (Table 2) according to the age of the players. Sprint and agility variables were measured by time so higher rate correspond to worse speed.

Then, because of the low number of participants for some age groups the researchers divided the age groups every two years as the formal classification system of Greece. The following table shows the correlations among anthropometric and performance factors according to the age of the players (Table 3). The minus and plus signs correspond to positive and negative correlations respectively.

Table 1. Descriptive statistics of anthropometric factors

Age		Height	Weight	Body fat	Body mass index
	N	M (SD)	M (SD)	M (SD)	M (SD)
U8	6	126.42 (5.84)	26.83 (5.43)	19.30 (4.24)	16.63 (2.19)
U9	6	135.08 (8.60)	33.92 (10.25)	21.73 (8.68)	18.38 (4.01)
U10	49	138.02 (4.90)	35.01 (6.60)	18.58 (4.64)	18.31 (2.59)
U11	26	143.15 (5.08)	38.60 (6.06)	19.22 (5.30)	18.78 (2.20)
U12	39	147.03 (4.90)	40.25 (7.24)	17.85 (5.89)	18.58 (2.75)
U13	31	153.81 (8.50)	46.02 (10.35)	14.61 (4.61)	19.27 (2.69)
U14	33	159.38 (8.41)	52.67 (9.04)	15.13 (5.17)	20.52 (2.78)
U15	54	167.79 (8.16)	58.14 (9.80)	13.10 (4.93)	20.57 (2.53)
U16	32	172.55 (5.96)	64.05 (8.80)	12.75 (3.88)	21.49 (2.31)
U17	22	172.80 (5.19)	66.11 (8.16)	12.01 (3.56)	22.12 (2.31)
U18	16	176.03 (7.08)	70.83 (7.79)	12.70 (3.06)	22.89 (2.37)

Table 2. Descriptive statistics of performance factors

Age		Vertical jump	10m sprint	20/30m sprint	Agility	VO2max
	N	M (SD)	M (SD)	M (SD)	M (SD)	M (SD)
U8	6	17.92 (3.75)	2.50 (.20)	4.51 (.35)	20.86 (1.31)	Not measured
U9	6	16.28 (3.79)	2.43 (.20)	4.45 (.33)	20.94 (1.64)	Not measured
U10	49	18.98 (2.86)	2.26 (.12)	4.07 (.25)	19.16 (1.16)	10.58 (.80)
U11	26	19.20 (3.37)	2.24 (.10)	4.02 (.22)	18.72 (1.03)	10.88 (.74)
U12	39	19.93 (3.55)	2.20 (.12)	3.93 (.24)	18.16 (1.03)	10.95 (.98)
U13	31	21.56 (3.34)	2.13 (.11)	3.75 (.22)	17.60 (.95)	11.32 (.57)
U14	33	23.44 (4.06)	2.10 (.12)	3.89 (.55)	17.18 (.85)	11.29 (.97)
U15	54	26.11 (4.31)	2.04 (.12)	4.28 (.65)	16.90 (1.01)	11.95 (1.01)
U16	32	29.16 (4.33)	1.99 (.13)	4.68 (.21)	16.30 (.78)	12.08 (.86)
U17	22	32.06 (4.29)	1.91 (.09)	4.53 (.22)	15.67 (.28)	12.23 (.92)
U18	16	32.11 (6.92)	1.91 (.10)	4.47 (.19)	15.81 (.44)	12.25 (.93)

Table 3. Correlations among the variables

Age		Vertical jump	10m sprint	20/30m Sprint	Agility	VO2max
		r	*r*	*r*	*r*	*r*
U8-9	Height	-.33	.08	.24	.25	Not measured
	Weight	-.75**	.38	.56	.54	Not measured
	Body Fat	-.88***	.47	.61*	.53	Not measured
	Body mass index	-.87***	.52	.67*	.62*	Not measured
U10-11	Height	-.11	-.01	-.07	.05	-.00
	Weight	-.28*	.29*	.21	.28*	-.22**
	Body Fat	-.52***	.46***	.45***	.44***	-.44***
	Body mass index	-.30**	.38***	.31**	.33**	-.30**
U12-13	Height	-.03	-.01	.03	.13	.05
	Weight	-.26*	.21	.27*	.41***	-.31**
	Body Fat	-.56***	.54***	.63***	.69***	-.62***
	Body mass index	-.37***	.33**	.37***	.53***	-.49***
U14-15	Height	.35***	-.35***	.07	-.33***	.21
	Weight	.11	-.01	.04	-.07	-.15
	Body Fat	-.47***	.54***	-.08	.54***	-.63***
	Body mass index	-.19	.30**	.02	.22*	-.41***
U16-17	Height	.03	.06	-.10	.14	.13
	Weight	.15	-.11	-.10	.24	.08
	Body Fat	-.05	.11	.17	.36**	-.24
	Body mass index	.17	-.16	-.08	.22	.03
U18	Height	-.33	.08	.24	.25	-.01
	Weight	-.75**	.38	.56	.54	.36
	Body Fat	-.88***	.47	.61*	.53	-.47
	Body mass index	-.87***	.52	.67*	.62*	-.52

** p<.05 ** p<.01 *** p<.001*

Multiple regression analysis was used to examine which of the anthropometric factors significantly predicted vertical jump, sprint, agility and VO2max, respectively (Table 4). The predictor variables entered simultaneously to the model. Players' aged U8-9 results indicated that the predictors explained 69.8% of the vertical jump variance (R^2= .81, $F_{(4, 7)}$ = 7.35, P = .01). Although the model explained the dependent variable very high no one predictor was significant enough. The results of the regression indicated that the predictors explained 59.4% of the 10m sprint variance (R^2= .74, $F_{(4, 7)}$= 5.01, P = .05). It was found that body fat (*β*= -3.09, P = .05) and body mass index (*β*= 8.79, P = .05) significantly predicted 10m sprint. The results of the regression indicated that the predictors explained 59% of the 20m sprint variance (R^2= .74, $F_{(4, 7)}$= 4.95, P = .05). It was found that only body mass index significantly predicted 20m sprint (*β*= 7.86, P = .05). The results of the regression indicated that the predictors explained 68.1% of the agility variance (R^2= .80, $F_{(4, 7)}$= 6.80, P = .05). It was found that body fat (*β*= -4.02, P = .01) and body mass index (*β*= 6.11, P = .05) significantly predicted agility. Players' aged U10-11 results indicated that the predictors explained 32.7% of the vertical jump variance (R^2= .36, $F_{(4, 70)}$= 9.99, P = .001). It was found that only body fat significantly predicted vertical jump (*β*= -1.03, P = .001). The results of the regression indicated that the predictors explained 19.9% of the 10m sprint variance (R^2= .24, $F_{(4, 70)}$= 5.59, P = .001). It was found that only body fat significantly predicted 10m sprint (*β*= .48, P = .05). The results of the regression indicated that the predictors explained 21.9% of the 20m sprint variance (R^2= .26, $F_{(4, 70)}$= 6.17, P = .001). It was found that only body fat significantly predicted 20m sprint (*β*= .69, P = .001). The results of the regression indicated that the predictors explained 17% of the agility variance (R^2= .22, $F_{(4, 70)}$= 4.80, P = .01). It was found that only body fat significantly predicted agility (*β*= .60, P = .01). The results of the regression indicated that the predictors explained 19.7% of the VO2max (R^2= .24, $F_{(4, 68)}$= 5.43, P = .001). It was found that only body fat significantly predicted VO2max (*β*= -.76, P = .001). Players' aged U12-13 results indicated that the predictors explained 30.1% of the vertical jump variance (R^2= .34, $F_{(4, 65)}$= 8.44, P = .001). It was found that only body fat significantly predicted vertical jump (*β*= -.81, P = .001). The results of the regression indicated that the predictors explained 28.3% of the 10m sprint variance (R^2= .33, $F_{(4, 65)}$= 7.83, P = .001). It was found that only body fat significantly predicted 10m sprint (*β*= .83, P = .001). The results of the regression indicated that the predictors explained 44.3% of the 20m sprint variance (R^2= .48, $F_{(4, 65)}$= 14.71, P = .001). It was found that only body fat significantly predicted 20m sprint (*β*= 1.10, P = .001). The results of the regression indicated that the predictors explained 47.7% of the agility variance (R^2= .51, $F_{(4, 65)}$= 16.74, P = .001). It was found that only body fat significantly predicted agility (*β*= .89, P = .001). The results of the regression indicated that the predictors explained 36% of the VO2max variance (R^2= .40, $F_{(4, 64)}$= 10.56, P = .001). It was found that only body fat significantly predicted VO2max (*β*= -.54, P = .01). Players' aged U14-15 results indicated that the predictors explained 35% of the vertical jump variance (R^2= .38, $F_{(4, 82)}$= 12.59, P = .001). It was found that body fat (*β*= -.67, P = .001), and weight (*β*= 1.38, P = .05) significantly predicted vertical jump. The results of the regression indicated that the predictors explained 34.3% of the 10m sprint variance (R^2= .37, $F_{(4, 82)}$= 12.23, P = .001). It was found that only body fat significantly predicted 10m sprint (*β*= .58, P = .001). The results of the regression indicated that there was not any significant prediction of 30m sprint by the model. The results of the regression indicated that the predictors explained 39.9% of the agility variance (R^2= .43, $F_{(4, 82)}$= 15.29, P = .001). It was found that only body fat significantly predicted agility (*β*= .83, P = .001). The results of the regression indicated that the predictors explained 38.5% of the VO2max variance (R^2= .41, $F_{(4, 82)}$= 14.49, P = .001). It was found that only body fat significantly predicted VO2max (*β*= -.71, P = .001). Players' aged U16-17 results indicated that there was not any significant prediction of vertical jump, 10m sprint, 30m sprint, agility and VO2max by the regression model. Although the non-significant model, the only significant predictor of 10m sprint, 30m sprint, agility and VO2max was body fat. The results of the regression indicated that there was not any significant prediction of vertical jump, 10m sprint, 30m sprint, agility and VO2max by the model for the age U18. Although the model was not significant, the predictor that better explained 30m sprint was body fat.

Table 4. Performance predictors

Age	Performance factors									
	Vertical jump		Sprint 10m		Sprint 20m-30m		Agility		VO2max	
	Beta	***B***	***Beta***	***β***	***Beta***	***β***	***Beta***	***β***	***Beta***	***β***
U8-9										
Body fat	-.39	-.70	-.09	-3.09*	-.11	-2.17	-.86	-4.02**	.59	4.08*
Body mass index	-3.63	-3.16	.52	8.79*	.79	7.86*	2.69	6.11*	-1.75	-5.82
U10-11										
Body fat	-.65	-1.03***	.01	.48*	.03	.69***	.14	.60**	-.13	-.76***
Body mass index	2.04	1.66	-.06	-1.29	-.14	-1.39	-.73	-1.59	.27	.86
U12-13										
Body fat	-.51	-.81***	.02	.83***	.05	1.10***	.16	.89***	-.08	-.54**
Body mass index	-.01	-.00	-.00	-.08	-.10	-1.09	.09	.23	-.09	-.29
U14-15										
Body fat	-.58	-.67***	.01	.58***	-.03	.02	.16	.83***	-.14	-.71***
Body mass index	-1.10	-.66	.01	.18	.18	.13	.02	.05	.02	.04
U16-17										
Body fat	-.37	-.30	.01	.40*	.03	.41*	.07	.39*	-.11	-.48**
Body mass index	-2.59	-1.32	.07	1.30	-.23	-2.23	.16	.53	.98	2.51
U18										
Body fat	-1.64	-.72	.02	.69	.08	1.18*	.11	.77	-.22	-.73
Body mass index	6.21	2.12	.12	2.83	-.26	-3.15	-1.06	5.69	1.67	4.2

** p<.05 ** p<.01 *** p<.001*

4. DISCUSSION

The study principally aimed to identify the relationships between anthropometric and performance factors and which one are stronger for different age groups. The correlations showed that body fat and body mass index were the variables that most correlated to the performance variables for almost all the age groups (from U10 to U17). However for groups U8-9 and U18, body fat and body mass index were mainly correlated to vertical jump. The regression models for each age group indicated that for players' aged U8-9, body fat predicted 10m sprint, agility and VO2max, as well body mass index predicted 10m sprint and agility. Players' aged U10-11 and U12-13 body fat predicted vertical jump, 10m sprint, 20m sprint, agility and VO2max. Players' aged U14-15 weight predicted vertical jump, while body fat predicted vertical jump, 10m sprint, agility, and VO2max. As far as the players aged U16-17 and U18 no one anthropometric factor related to performance factors. The results showed that in contrast to the literature review that supports a relationship between both height and weight with performance factors [14,15,16] there was not any significant relationship for most of the age groups. However, the most important factor that was related to performance was primarily body fat and secondarily body mass index [17]. Specifically, body fat is an important performance indicator for players aged from 10 to 15 years old. In total the findings show that although anthropometric variables are significant in younger age groups, later other variables affect the performance of older players more. The reduction of relationship among anthropometric and performance factors in older age groups heighten the significance of avoiding talent identification by anthropometric factors in early ages [30]. Furthermore, body fat that affects the performance in early ages is not a constant variable, which in contrast changes through training [19]. Thus talent identification should be based on technical skills which are identified as the most determinant factor of elite young players [31]. Furthermore, other characteristics such as experience, personality, and relative age of each player should be included in talent identification systems [5,32]. It is suggested future research to develop multifunctional soccer tests that examine psychological, physiological, and technical factors according to the requirements of each age.

5. CONCLUSION

In conclusion the study shows that anthropometric characteristics such as body fat and then body mass index determine the performance of the players. Specifically, body fat was the most important predictor of performance factors for players aged from 10 to 15 years old. Thus it is crucial for coaching and training staff to assess anthropometric characteristics very frequently throughout the season. Then it would be possible for them to target the training sessions in improving factors that affect the performance.

ETHICAL APPROVAL

The University Research Ethics Committee granted approval for the current study

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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