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RELATIONSHIPS BETWEEN SKINFOLD THICKNESS, BODY MASS INDEX AND PHYSICAL FITNESS OF FEMALE STUDENTS

Key words: physical fitness, AAHPER test, skinfold thickness, BMI.

ABSTRACT

The purpose of this study was to examine the relationship between physical fitness, skinfold thickness and body mass index (BMI) of 11-13-year-old female students in order to use the obtained data and knowledge to improve students' physical fitness. Three hundred eight female students randomly selected participated in the study. Skinfold fat measurements were taken from three regions of the body (triceps, quadriceps and suprailiac muscles) with a Harpenden Caliper (HSK–BI). The subjects were divided into three categories with regard to the amount of body fat: high, medium and low. Jackson and Pollock body density equations were used and students' BMI was measured. Students' physical fitness was evaluated with AAHPER tests such as flexibility, sit-up, bar (horizontal bar) and 540 m run. Data were analyzed with Pearson's correlation coefficient using SPSS for Windows. The results revealed significant correlations between physical fitness tests and body fat percentage ($p < 0.001$). The results also showed a significant positive relationship between BMI and skinfold thickness ($r = 0.0294$, $p < 0.001$).

INTRODUCTION

One of the main objectives of physical education is development of human organs and body systems. It is realized through development of physical fitness in accordance with individual needs. In this way, the ability to tolerate physical stress, recover, feel well and resist fatigue can be attained [9]. An appropriate planning and evaluation of physical education can help students achieve these goals. Evaluation in school PE lessons is one of methods assessing students' physical ability to motivate them to participate in physical activities and improve their physical and motor condition [14]. In recent years, certain trends have been established by experts to appropriate evaluation of students' performance, and effective assessment tests have been designed. An important problem is that such evaluations have been carried out regardless of differences in students' physical structure [10]. The question remains how to make assessment data available to the coach or the PE teacher more accurate and realistic so that students' preparation and performance can be improved.

Adjustment of physical education courses with regard to individual differences and body types in terms of body fat percentage (high, medium, low) can be achieved through effective steps via preparation and application of relevant norms in schools to increase students' health and happiness [12]. Kei Mak (2009) studied the weight and fitness of Hong Kong adolescents and showed that obese, overweight and underweight individuals attained lower results in sit-up and bar tests [6] than

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their normal weight counterparts. In a study of physical fitness of sports science students, Masaaki (2008) found a significant difference in BMI between men and women and suggested that in order to accurately assess and provide reliable norms of fitness tests students' age and gender should be taken into account [8].

Ching et al. (2007) assessed BMI and health related physical fitness of 9-18-year-old adolescents from Taiwan and concluded there was a non-linear relationship between BMI and physical fitness, which increased with age [2]. Sardinha (1999) examined lean body mass, skin fold thickness of triceps and arm circumference as criteria for obesity identification in children and adolescents [15]. Arress et al. conducted research on skinfold thickness and performance of elite endurance runners and demonstrated that the subcutaneous fat thickness in the lower limb (thigh and calf) depended on long-term running experience. This observation can be useful for predicting runners' performance [1]. According to Manyeki et al., who studied body size, body composition and physical fitness of children in Alysras, there are significant positive correlations between body height, body weight and long jump and sit-up tests results in children of both sexes. They also revealed significant negative relationships between 50 m running test results, body height, body weight and skinfold and BMI [11]. Gaeini et al. assessed relationships between body fat and BMI in females and observed a strong positive correlation between body fat percentage and BMI (r = 0.61) [3]. According to literature, in determining the level of performance and motor abilities of students of different ages as well as objectives of physical education in the development of students' motor skills, standard scientific criteria are essential.

The present study can provide useful information about the level of skills and physical fitness of students with regard to individual differences, skinfold and body mass index, and help improve students' physical fitness and encourage them to participate more cagerly in physical education classes at school.

METHODS

The sample consisted of 318 secondary school female students from Hoveyzeh, Iran, aged 11-13 years, who attended their schools in the years 2010-2011. Skinfold thickness was measured with the use of Jackson and Pollock body density equations for females:

$$BD = 1.1470292 - 0.0009376\ (x_3) + 0.0000030\ (x_3)^2 - 0.0001156\ (x_4) - 0.0005839\ (x_5)$$

X_3 = total fat measurement from three areas of the body (triceps, quadriceps and suprailiac muscles)
X_4 = subjects' age
X_5 = hip circumference (cm)
BD = body density
%BF = body fat percentage

$$\%BF = [(\frac{4/57}{DB})] - 142/4] \times 100$$

Physical fitness tests included sit-up, flexibility, modified bar and 540 meters running. The subjects were divided into three categories (high, medium, low), according to their percentage of body fat. After the performance of necessary measurements and collection of data the relationship between body fat percentage and subjects' scores in AAHPER tests was examined with the use of Pearson's correlation coefficient.

RESULTS

Tables 1-6 present subjects' characteristics and descriptive statistics such as means, standard deviation, and minimum and maximum scores of each test.

Table 1. Descriptive statistics of characteristics of 11-year-old female students

BF% \ Variable		Height (cm)	Weight (kg)	BF%	$^{kg}/_{m^2}$ BMI
High	Max	164	76	29.57	30.26
	Min	125	41	20.02	25.03
	SD	8.03	7.10	2.92	1.34
	Mod	156	60	20.02	25.03
	Median	153	61	26.29	26.15
	Mean	152	61.27	22.50	26.39
Medium	Max	163	60	19.30	24.94
	Min	142	41	15.92	20.04
	SD	5.75	4.31	1.13	1.12
	Mod	157	48	15.92	21.91
	Median	153	50	17.17	21.84
	Mean	151	50.66	17.33	21.94
Low	Max	165	47	15.69	19.43
	Min	124	30	10.13	14.95
	SD	8.10	4.51	1.70	1.12
	Mod	140	35	10.13	17.85
	Median	149	38	11.52	16.88
	Mean	148/36	38.12	12.31	17.08

Table 2. Descriptive statistics of physical fitness test results of 11-year-old female students

BF% \ Variable		Bar (trails)	Sit-up (trails)	Flexibility (cm)	540 m run (min)
High	Max	18	45	48	4.50
	Min	2	22	29	3.08
	SD	3.88	6.69	5.67	0.39
	Mod	15	39	41	3.30
	Median	17	3	40	3.38
	Mean	16	35	39	3.53
Medium	Max	25	50	49	3.92
	Min	2	30	25	2.33
	SD	3.94	5.96	7.10	0.45
	Mod	19	34	30	2.36
	Median	21	41	38	3
	Mean	20	40	37	3.02
Low	Max	22	50	50	4.00
	Min	1	8	16	2.22
	SD	5.53	10.14	8.64	0.47
	Mod	21	31	30	3.45
	Median	18	36	37	3.41
	Mean	16	34	35	3.31

Table 3. Descriptive statistics of characteristics of 12-year-old female students

BF% \ Variable		Height (cm)	Weight (kg)	BF%	$^{kg}/_{m^2}$ BMI
High	Max	164	81	32.76	36.42
	Min	125	54	23.41	25.28
	SD	8.03	7.33	3.19	2.49
	Mod	156	60	23.41	25.28
	Median	153	71	26.53	27.54
	Mean	152	69	27.39	27.96
Medium	Max	163	49	23.12	24.97
	Min	142	41	14.39	20.06
	SD	5.75	15.94	2.50	1.58
	Mod	157	50	14.39	20.81
	Median	153	52	17.50	21.96
	Mean	151	55	18.31	22.16
Low	Max	165	53	13.51	19.62
	Min	124	32	6.18	13.49
	SD	8.10	4.85	1.77	1.30
	Mod	140	40	6.18	16.02
	Median	149	41	11.02	17.08
	Mean	148.36	41	10.64	16.86

Table 4. Descriptive statistics of physical fitness test results of 12-year-old female students

BF% \ Variable		Bar (trails)	Sit-up (trails)	Flexibility (cm)	540 m run (min)
High	Max	19	39	40	3.56
	Min	2	5	23	2.00
	SD	5.49	8.98	4.91	0.69
	Mod	10	33	30	4.16
	Median	10	24	31	3.49
	Mean	10	23	30	3.60
Medium	Max	26	51	50	3.56
	Min	3	8	15	2.00
	SD	6.10	11.48	10.07	2.93
	Mod	23	25	30	2.54
	Median	18	32	32	3.08
	Mean	16	32	33	3.49
Low	Max	23	50	48	4.52
	Min	4	12	15	2.32
	SD	7.27	9.27	7.98	0.64
	Mod	10	26	32	2.32
	Median	17	31	30	4.01
	Mean	15	31	29	3.25

Table 5. Descriptive statistics of characteristics of 13-year-old female students

BF% \ Variable		Height (cm)	Weight (kg)	BF%	$^{kg}/_{m^2}$ BMI
High	Max	169	81	33.20	31.05
	Min	148	49	23.51	25.03
	SD	5.12	7.11	2.92	1.75
	Mod	156	69	23.51	25.23
	Median	160	67.5	26.87	26.53
	Mean	159	67.63	27.67	26.87
Medium	Max	170	60	23.28	30.13
	Min	148	48	18.19	20.13
	SD	5.90	4.57	1.63	1.81
	Mod	152	49	18.19	20.77
	Median	159	54	20.48	21.56
	Mean	158	53	20.73	21.76
Low	Max	167	58	13.70	18.24
	Min	138	30	13.82	18.79
	SD	5.26	5.77	8.17	16.72
	Mod	156	48	2.81	1.52
	Median	156	46	8.17	13.19
	Mean	156	45	17.80	19.91

Table 6. Descriptive statistics of physical fitness test results of 13-year-old female students

BF% \ Variables		Bar (trails)	Sit-up (trails)	Flexibility (cm)	540 m run (min)
High	Max	16	39	40	4.38
	Min	2	11	22	2.57
	SD	4.36	8.36	4.76	0.40
	Mod	10	27	29	3.19
	Median	12	25	29	3.44
	Mean	12	55	30	3.48
Medium	Max	26	50	50	4.11
	Min	4	17	23	2.20
	SD	6.97	7.46	6.89	0.48
	Mod	17	35	30	2.20
	Median	15	32	35	4.09
	Mean	14	32	34	3.06
Low	Max	24	49	50	4.00
	Min	3	7	13	2.24
	SD	7.29	10.35	8.66	0.48
	Mod	21	20	30	3.10
	Median	18	33	33	3.11
	Mean	16	31	33	3.08

A significant negative correlation was found between sit-up scores and BF% ($r = –0.263$, $p<0.01$). On the other hand, the test results also showed that endurance of abdominal muscles was inversely correlated with body fat percentage, and that there was a significant negative correlation between modified bar scores and subjects' BF% ($r = –0.245$, $p<0.01$).

There was also a significant negative correlation between flexibility of waist and posterior thigh muscles and BF% ($r = –0.244$, $p<0.01$). The results revealed that the flexibility of the thigh and the waist had an inverse relationship with body fat percentage. Significant correlations were also found between 540 m running scores and subjects' BF% ($r = 0.403$, $p < 0.01$), and between skin fold fat thickness and body mass index ($r = 0.0249$, $p<0.01$), which meant that there was a direct correlation between BMI and subjects' BF%.

DISCUSSION

Numerous studies have indicated that body composition, body type and posture are closely associated with health, physical fitness and athletic performance [5]. According to the World Health Association a high level of body fat is a serious health threat, and obesity can lead to numerous health problems such as hypertension, high blood fat and diabetes [13]. Body composition plays an important role because a high volume of lean body mass (LBM) means a higher working capacity, while a high proportion of fatty tissue has a negative relationship with the capacity to work. Overweight caused by adiposity adds to the load and resistance to body movements and exceeding fat can limit the movement range of the human body. An appropriate body composition is vital to success in some sports [4]. The results of the present study demonstrate that body composition with regard to BF% is one of success factors in students' physical fitness level, and that scores in physical fitness tests (sit-up, flexibility, bar, 540 m run) decrease with an increase in skinfold thickness. Subjects with moderate amounts of skinfold fat gain better results in comparison with subjects with high or low skinfold thickness.

There is a significant positive relationship between body fat percentage and body mass index ($r = 0.294$, $p<0.01$), which means a highly likely direct relationship can be noted between BMI and students' BF% as well as between physical fitness scores and body fat percentage (sit-up, –0.263, flexibility –0.244, bar –0.245 and 540m run –0.403). Thus the relationship between physical fitness and BF% is an inverse one. The findings of the present study correspond with the results of Kei (2009), Massaki (2008) and Arress (2006), who found a significant correlation between BF% and subjects' performance. Other researchers, e.g. Gaeini, Ziaei and Pollock (1980), revealed a significant relationship between BF%, body weight, BMI and physical fitness, which also supports the results of the present study [3, 13, 18].

Naser (2006) in a study on standardization of PE fitness tests based on BMI and skin fold measures in high school students found a significant correlation ($r = 0.727$) between BMI and BF%, and between BF% and success in physical fitness tests, which again confirms the results of the present study [12].

On the other hand, Seyyed (2007) concluded there was no significant correlation between flexibility and sit-up tests results in female college students [16]. Sex and age differences maybe the reasons behind these different findings. Also such factors as geographical, social and economic conditions should be considered in the discussion of these differences. The study results show that subjects in all three age ranges maintain good physical fitness. It seems that an active and rural lifestyle can be a factor accounting for this quality. With the use of results of this investigation regarding individual differences, based on body fat content, physical education teachers and coaches can provide norms based on BF% and BMI to assess students' performance and physical fitness using three lean body types: low fat, muscular (medium fat) and overweight (high fat). This categorization can be recommended for the purpose of assessment school students' physical fitness. In this view, nationwide investigations of physical fitness at schools in order to provide effective standards for assessing fitness development of young people should be considered a major priority.

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REFERENCES

[1] Arress A.L., Ostariz E.S., Skin fold thicknesses associated with distance running performance in highly trained runners, *Journal Sport and Science*, 2006, 24 (1): 69-76.

[2] Ching Y.H., Robert M., BMI and health- related physical fitness in Taiwanese youth 9-18 years, *Journal of Medicine and Science in Sport and Exercise*, 2007, 39 (4): 701-708.

[3] Gaeini A., Lameei T., Relationship between body fat percentage (BF%), body mass index (BMI) and waist to hip (WHR) of women over 15 years from Tehran, *Harekat*, 2003, 17: 95-105.

[4] Heyvoud M.K., Text book of growth and motor development in lifespan, Samt Publications, Iran: Tehran 2001.

[5] Acland T.R., Schreiner A.B., The elite athlete assessing body shape, size, proportion and composition, *Journal of Clinical Nutrition*, 1995, 4: 25-29.

[6] Kei M.K., Yinho S., Szelo W., Tomas G.N., Health-related physical fitness and weight status in Hong Kong adolescents, *BMC Public Health*, 2009, 10: 458-471.

[7] Khavari L., Nazem F., Farahpour N., Yousefian J., Assessment of pattern of skin fold, BMI, body density and body type changes of 13-17-year-old girls in Hamadan. *Harekat*, Iran, 2004, 30: 139-150.

[8] Massaki T., Seiji Y., Kaoru M., Physical fitness assessment of students at Osaka University of health and sport sciences, *Japans Bulletin of Osaka College of Physical Education*, 2008, 39: 199-214.

[9] Moharramzadeh M., Mohamadzadeh H., Study of physical fitness level of students of Urmia university. *Harekat*, Iran, 2000, 4: 103-117.

[10] Mojtahedi H., Text book of evaluation and measurement in physical education. Isfahan University Publication, Isfahan 1999.

[11] Monyeki M., Toriola A., Monyeki K., Brits S., Pienaar A., Body composition and physical fitness of Ellisras rural children, South Africa, *Journal for Physical, Health Education and Dance*, 2004, 10 (2): 154-162.

[12] Naser K., Standardizing the physical fitness tests of physical education course based on BMI and skin fold measures in students of high schools. Shahid Chamran Publication, Ahwaz 2006.

[13] Pollock M.L., Smchmidt D.H., Jackson A.S., Measurement of cardio-respiratory fitness and body composition in the clinical setting, *Comprehensive Therapy*, 1980, 6 (9): 12-17.

[14] Pouyanfar A.R., Textbook of Teaching Methods of Physical Education in Secondary Schools. Physical Education Organization Publication, Ministry of Education, Tehran, Iran 1997.

[15] Sardinha B.L., Going B.S., Teixeria P., Lohman G.T., Receiver operating index, triceps slickness and arm girth for obesity screen in children and adolescents, *American Journal of Clinical Nutrition*, 1999, 70 (6): 1090-1095.

[16] Seyyed A., Standardization of the physical education course based on skinfold measurements of college females of Behbahan universities. Behbahan University Publication, Iran, Behbahan 2007.

[17] Wilmore J.H., Buskirk E.R., Digirolamo M., Lohman T.G., Body composition, around table, *The Physicians and Sport Medicine*, 1986, 14 (3): 144-162.

[18] Ziaee V., Fallah J., Rezaee M., Biat A., The relationship between body mass index and physical fitness in 513 medical students, *Tehran University Journal*, 2007, 65: 79-84.