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The Relationship of BMI, Fat Percentage, and Waist-Hip Ratio to Physical Fitness Factors in Female Students

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ABSTRACT

Aim: The aim of the present research was to examine the relationship of BMI, fat percentage, and waist-hip ratio to physical fitness factors in female students.
Procedure: 450female students of Yazd University (19-25 yrs.) were randomly selected as the sample. The subjects were classified into obese, normal, and lean groups. Height and weight were measured for BMI, subcutaneous fat was measured at two point (triceps and suprailiac) for fat percentage using a caliper, and waist and hip circumference was measured for waist-hip ratio (WHR). As for physical fitness factors, cardiorespiratory endurance was measured using 20-m shuttle run, abdominal endurance was measured by sit-ups, handgrip strength was measured using a dynamometer, and flexibility was measured by trunk flexion test. Descriptive statistics, Pearson correlation coefficient, and a simultaneous regression model were used for data analysis.
Results: In all the subjects, the components of body composition were negatively associated with cardiorespiratory fitness. BMI was negatively related to abdominal endurance, but no significant relationship was observed between BMI and other body composition components. There was a significant positive relationship between the components of body composition and handgrip strength. Body fat percentage and BMI were positively associated with flexibility, while WHR was not related to flexibility.
Conclusion: Cardiorespiratory fitness and abdominal endurance are negatively related to body composition components. Body composition can indirectly indicate the level of certain physical fitness factors. Thus, it is recommended to encourage female students to reduce their fat mass for increased endurance.
KEYWORDS: Body composition, waist-hip ratio, fat percentage, physical fitness.

1. INTRODUCTION

Obesity, as the result of a sedentary lifestyle, is the disturbance in body composition as relative or absolute increase in the level of body fat mass. Prevalence of obesity is increasing in most developing countries[1-3] and it can be regarded as the most widespread epidemic in the world[4]. At present the prevalence of obesity among adults is 10-40% in different countries [4, 5].The prevalence of obesity and overweight in Iran has been reported 23% and 40% respectively[6]. Obesity increases the risk of different diseases such as malignancies[7], diabetes mellitus type 2[1, 8-10], and cardiovascular diseases [11]and it reduces life expectancy. Also low levels of health-related physical fitness is associated with obesity, diabetes mellitus type 2, high blood pressure, increased cholesterol, metabolic syndrome, cardiovascular diseases, and many causes of fatality[12-14]. Understanding the link between the level of physical fitness and obesity in youths has received much attention [15]. Due to the incidence of osteoporosis in women, sport and physical fitness are necessary for maintaining bone mass and can contribute to building of stronger bones providing that necessary amounts of calcium are consumed[16].

Unfortunately the sport culture is not well taken by Iranian women many of whom live sedentary lifestyles, and obesity is one of the major consequences of sedentariness. Iranian women, as the most important targets of obesity, require sport and physical exercise to maintain their health, fitness, and vivacity[8]. Studies have shown that obese and overweight individuals have poorer performance in physical fitness tests and negative correlation has been observed between health-related physical fitness and obesity[17-19]. These studies are specifically important since physical fitness is a predictor of health. However, there are few studies that have examined the relationship between health-related physical fitness and a set of obesity indicators (e.g. BMI, WHR, and fat percentage). Therefore, the present research was carried out to study the relationship between the components of body composition and health-related physical fitness in 19-25-year-old female students.

METHODOLOGY

The present research was cross-sectional, carried out on healthy, non-athlete female students (19-25 yrs.) of Yazd University. Students were asked to participate in the study by an ad in the university bulletin. 650 students

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volunteered to take part in the tests. After excluding ill students, 628 students were eligible to take the test, and 458 students were randomly selected as the sample. All the subjects completed a consent form. Anthropometric characteristics as well as health-related physical fitness were measured for all the participants. The former included height, weight, body mass, subcutaneous fat (two regions), waist circumference, hip circumference, andtotal body fat. Seca scale (Hamburg, Germany) was used to measure the weight of the participants. Height was measured by tape measure in the standing erect position with the heels, hip, shoulders, and back of the head touching a wall without any footwear. To determine total body fat percentage, subcutaneous fat was measured at two regions (triceps and suprailiac) using a caliper (Yagami, Japan)and the two-point method and Sloan-Weir formula were used for this measurement [8].20-m shuttle run (cardiorespiratory fitness),sit-ups (abdominal endurance), dynamometer (Jamar, USA) (handgrip strength), and sit-and-reach test (trunk and hip flexibility) were used for measuring health-related physical fitness. Participation in the research project was voluntary, ethical issues were observed in measuring parameters, the results were provided to the participants, and they were consulted for improving their anthropometric characteristics. The participants were divided into three groups: lean (BMI less the 18.5 kg/m^2), normal (BMI between18.5 and 25kg/m^2), and obese (BMI greater than 25kg/m^2)[20].

Statistical procedure

Descriptive (mean, median, and standard deviation) and inferential statistics (Pearson correlation coefficient and a simultaneous regression model) were used for data analysis. All the operations were done in SPSS 20 at the 0.05 significance level.

Findings

The results showed that in the studied sample ($n = 450$), 22.4% were lean ($n = 101$), 66.6% were normal (n=297), and 11.67% were obese or overweight ($n = 52$). The mean height (162.4 cm), weight (56.05 kg), BMI (21.19 kg/m^2), WHR (0.84), and body fat percentage (31.15%) was measured (Tables 1 and 2).

Table 1) health-related physical fitness parameters

Variables	Body Composition	max	min	median	M ±SD
Cardio-Respiratory Fitness (f)	lean	33	18	29	27.8±3.58
	normal	33	17	28	26.8±3.76
	obese	28	17	22	22.5±2.85
	total	33	17	28	26.6±3.93
Abdominal Endurance (f/min)	lean	53	18	37	35.1±8.79
	normal	56	15	36	34.4±7.98
	obese	46	16	33.5	31.9±9.56
	Total	56	15	36	34.3±8.40
Hand Grip Strength (kg)	lean	33	16	25	24.7±3.93
	normal	41	14	28	27.4±4.94
	obese	35	18	29	28.9±3.78
	total	41	14	27	27.0±4.79
Flexibility (cm)	lean	22	-15	7	6.4±8.23
	normal	25	-15	9	8.6±7.65
	obese	23	-15	12	12.0±7.33
	total	25	-15	9	8.5±7.88

Table 2) Anthropometric characteristics

variables	Body Composition	max	min	median	M ±SD
BMI (kg/m2)	lean	18.49	14.52	17.75	17.3±0.95
	normal	25.00	18.25	21.3	21.4±1.76
	obese	30.43	25.04	27.16	27.3±1.61
	total	30.43	14.52	20.73	21.1±3.22
body fat percentage (%)	lean	32.37	17.14	24.6	24.2±3.34
	normal	43.06	18.54	31.64	31.7±4.64
	obese	54.94	32.35	40.57	40.9±5.43
	total	54.94	17.14	30.87	31.1±6.44
WHR (cm)	lean	0.89	0.73	0.82	0.8±0.03
	normal	0.96	0.73	0.85	0.8±0.04
	obese	1.01	0.7	0.86	0.8±0.05
	total	1.01	0.73	0.84	0.8±0.04

After calculating the means of health-related physical fitness variables and comparing them with norms provided by the Ministry of Education, it was revealed that the studied sample did very poor in cardiorespiratory fitness and did average in abdominal endurance, handgrip strength, and flexibility. Considering the ranking of the studied sample that can somehow represent the population in terms of body composition and health-related physical fitness, it can be argued that the population is in a poor to average condition in physical fitness. Thus, it is imperative that Iranian women pay special attention to losing weight and improving health-related physical fitness through appropriate exercise programs.

The results of Pearson correlation coefficient show that cardiorespiratory fitness is negatively associated with body fat percentage ($r = -0.279, p = 0.001$), WHR ($r = -0.174, p = 0.001$), and BMI ($r = -0.398, p = 0.001$). There is a weak negative correlation between abdominal endurance and BMI ($r = -0.093, p = 0.05$). However, abdominal endurance is not significantly correlated with WHR ($p > 0.05$).Handgrip strength is positively correlated with body fat percentage ($r = 0.238, p = 0.001$), WHR ($r = 0.145, p = 0.002$), and BMI ($r = 0.257, p = 0.001$).Flexibility in waist and hip muscles is also positively correlated with body fat percentage ($r = 0.158, p = 0.001$) and BMI ($r = 0.204, p = 0.001$), but it is not significantly correlated with WHR ($p > 0.05$).

Simultaneous regression analysis is used to examine the relationship between the components of body composition and physical fitness factors (Table 3).

Table3) Regression Coefficients Of Body Composition And Health Related Physical Fitness

Variables		Unstandardized Coefficients		Standardized Coefficients	t	Sig
		B	Str Error	Beta		
Cardio-Respiratory Fitness (f)	Constant	39.601	3.048		12.993	0.001
	body fat %	0.088	0.046	0.144	0.046	0.056
	WHR	-3.306	3.868	-0.040	-0.855	0.393
	BMI	-0.611	0.092	-0.500	-6.663	0.001
Abdominal Endurance (f/min)	Constant	48.153	7.081		6.801	0.001
	body fat %	0.093	0.107	0.071	0.870	0.385
	WHR	-11.516	8.987	-0.066	-1.286	0.199
	BMI	-0.327	0.213	-0.126	-1.537	0.125
Hand Grip Strength (kg)	Constant	15.635	3.918		3.990	0.001
	body fat%	0.053	0.059	0.072	0.897	0.370
	WHR	4.806	4.973	0.048	0.966	0.334
	BMI	0.269	0.118	0.181	2.281	0.023
Flexibility (cm)	Constant	16.895	6.479		2.608	0.009
	body fat%	0.018	0.098	0.015	0.183	0.855
	WHR	-26.086	8.223	-0.159	-3.172	0.002
	BMI	0.618	0.195	0.252	3.169	0.002

Based on the data in Table 3, the coefficient of determination is 0.166 for the relationship between body composition components and cardiorespiratory fitness. This coefficient shows the amount of variance explained by the model and takes a value between zero and one. The closer this coefficient is to one, the stronger will be the relationship. Since the significance level of the F-test is less than 0.05 ($p = 0.001$), there is a significant linear relationship between the criterion and predictor variables.

The non-standardized and standardized coefficients are presented along with their significance level. The non-standardized coefficients represent the coefficients of the variables in the regression model, and standardized coefficients are used to show the intensity of the relationships and take a value between zero and one. The closer they are to one, the stronger will be the relationship. Considering the table, only BMI has a significant effect on cardiorespiratory fitness.

Regression equation

$$\text{Cardiorespiratory Fitness} = 39.60 + 0.088\%\text{BF} - 3.306\text{WHR} - 0.611\text{BMI}$$

Since the significance level of F-test is greater than 0.05 ($p = 0.114$) for the relationship between body composition components and abdominal endurance, there is no significant linear relationship between the criterion and predictor variables. Thus, the regression model is not significant.

The significance level of F-test is less than 0.05 ($p = 0.001$) for the relationship between body composition components and handgrip strength. Thus, there is a significant linear relationship between the criterion and predictor variables. However, the table shows that only BMI has a significant effect on handgrip strength.

Regression equation

Handgrip Strength = 15.63 + 0.053%BF – 4.81WHR – 0.269BMI

The significance level of F-test is less than 0.05 ($p = 0.001$) for the relationship between body composition components and flexibility. Thus, there is a significant linear relationship between the criterion and predictor variables. The table shows that BMI and WHR have a significant effect on handgrip strength.

Regression equation

Flexibility = 16.89 + 0.018%BF – 26.09WHR – 0.618BMI

DISCUSSION AND CONCLUSION

The results of this study showed that there is a significant negative relationship between body composition components and cardiorespiratory fitness. Bovet et al. (2007) also examined the relationship between obesity and overweight and physical fitness, and used shuttle run for measuring VO_2 max. They showed that there is a strong negative correlation between physical fitness and overweight in adults [16]. Tovaret al. (2008) examined the overweight and physical fitness and reported a significant negative relationship between overweight and aerobic fitness[21]. Also McGovaket al. (2009) investigated the relationship between overweight and cardiorespiratory fitness and showed that increased BMI is significantly related to reduced cardiorespiratory fitness [3]. Napradit and Pantaewan (2009) examined the relationship between anthropometric indices and physical fitness. They came to the conclusion that BMI is negatively associated with cardiorespiratory fitness [22]. Sandercock et al. (2010) assessed secular changes in BMI and cardiorespiratory fitness (20-m shuttle run)in 10-year-old children and reported a significant negative relationship between BMI and cardiorespiratory fitness[23]. Moliner-Urdiales et al. (2011) examined the association between total and central fat mass and physical fitness. They assessed cardiorespiratory fitness with 20-m shuttle run and concluded that cardiorespiratory fitness is negatively associated with total and central body fat [24].

The present research showed that, among the components of body composition, only BMI was negatively associated with abdominal endurance. Brunet et al. (2007) studied the association between physical fitness and body composition and found that BMI is negatively associated with performance in sit-ups test [25]. Bovet et al. (2007) examined the relationship between obesity and physical fitness and reported a strong inverse relationship between fitness and excess body weight in adolescents [16]. Esco et al. (2010) studied the relationship between selected anthropometric variables and performance in sit-ups and push-ups tests and reported a negative relationship between BMI and sit-ups performance [9]. Huang and Malina (2010) evaluated the relationship between BMI and four components of physical fitness including abdominal strength/endurance and found that higher BMI was associated with poorer performance in the sit-ups test [2].

The present research indicated a significant positive relationship between handgrip strength and the components of body composition. Artero et al. (2010) examined health-related fitness in adolescents who were classified into underweight, normal weight, and overweight based on BMI. They found a significant positive relationship between BMI and handgrip strength[8].Vara et al. (2011) investigated the relationship between anthropometric variables and performance in maximum muscle strength and endurance and maximum aerobic capacity tests. They measured maximum strength with isometric bench press, splitting, and handgrip strength and found that BMI and maximum isometric strength are positively correlated [26].Merkiel and Chalcarz (2011) studied the relationship between physical fitness and BMI and found that BMI is positively correlated with strength in boys and girls [27].

The present research showed that there is a significant positive relationship between flexibility and body fat percentage and between flexibility and BMI. Huang and Malina (2010) examined the relationship between BMI and four physical fitness factors and reported a positive relationship between BMI and flexibility [2].Further, Malina et al. (1995) reported a significant negative relationship between obesity and flexibility [28].Except a handful of studies, most studies have reported a significant negative relationship between body composition components and cardiorespiratory fitness. Overall, the results of the present research support this negative relationship. Based on the present findings and the literature, we can conclude that there is a significant inverse relationship between abdominal endurance and obesity as well as BMI. This paper did not find any significant relationship for body fat percentage and WHR and many contradictory results can be seen in other studies. The reason for such inconsistency could be due to differences in instruments or even the studied population. Moreover, significant positive relationships were observed between the components of body composition and handgrip strength and flexibility (except for the relationship between flexibility and WHR which was not significant). However, there are significant inconsistencies in the results of other studies. As mentioned earlier, some studies have reported a significant negative relationship between BMI and handgrip strength, while others

have reported otherwise. Regarding flexibility, despite being less considered than other physical fitness factors, several studies have argued that flexibility is not associated with anthropometric variables, while few others have reported otherwise. Considering this inconsistency, further research is recommended on this issue to provide a better insight of the importance of flexibility in health and fitness.

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