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Relationships between body mass index and skinfold thickness of exercised and sedentary young adults#

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ABSTRACT

Both body mass index (BMI) and sum of skinfold thickness (SST) are interchangeably used in the assessment of body composition in young adults. Thus, this study aims to investigate the relationship between BMI and SST in young adults depending regular physical activity. The data were collected from a total of 611 young participants including 500 males and 111 females aged 18 to 21 years old students with cross sectional design. The volunteer participants of this study were divided into 4 groups as exercised males (EM), sedentary males (SM), exercised females (EF) and sedentary females (SF), respectively. SST measurements were taken by the Holtain skinfold caliper. Pearson correlation coefficient analysis was used to determine the relationships between due to correlational design of this study. This study showed that the significant relationship between BMI and SST in females was higher than in males depending on exercise participation. The correlations between BMI and SST were highest for EF, second highest for SM and the lowest for EM and SF. In general, males appear to have twice the average SST of females. In conclusion, the relationship between BMI and SST varies depending on the height and body weight, gender and participation in physical activity. In the absence of valid and complex method, the body fat percentage can be strongly estimated by BMI in exercised females than sedentary counterparts.

Keywords: Body mass index, sum of skinfold thickness, regular physical activity, age, gender.

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INTRODUCTION

Overweight and obesity as an excessive fat accumulation in the body, are increasingly threatening health (UNICEF et al., 2015). Body mass index (BMI) to determine overweight and obesity in adults is a simple index that shows the appropriate body weight for current body height. Since it is relatively difficult to measure body fat by direct methods in laboratory settings, it is important to determine whether field methods such as body mass index (BMI) and total skinfold thickness can be used interchangeably to evaluate body composition. In some studies, it was reported that BMI changes may not accurately reflect changes in body fatness (Demerath et al., 2006; Zorba and Ziyagil, 1995; Daniels et al., 1997). Although BMI can be used at certain confidence intervals as an indicator of body fat mass (Pietrobelli et al., 1998), changes in BMI also reflect changes in the size and number of body fat tissue (Rolland-Cachera et al., 2003). Within the limitations of cross-sectional studies, skinfold thickness has not been shown to provide a more accurate assessment of metabolic risk compared to BMI (Freedman et al., 2015).

On the other hand, skinfold thickness was taken by skinfold caliper from the selected anatomical points in the evaluation of body composition (Hume and Marfell-Jones, 2008). Skinfold measurement is a simple, inexpensive and practical way to evaluate body composition. Equations can be developed based on the measurements of the more precise laboratory techniques to measure the thickness of skinfolds in various regions to estimate body fat ratio. In skinfold assessment, it covers measurements of the thickness of skinfolds in various locations of the body. The sum of the thickness of the skinfolds is used as an indirect body fat measurement (Fahey et al., 2019).

Although children and adolescents with high BMI levels also tend to have high body fat (Krebs et al., 2007). BMI with consisting of fat mass and lean body mass, may be a weak indicator of obesity in those with normal or relatively low body fat percentage (Bray et al., 2002; Freedman and Sherry, 2009).

According to American National Institutes of Health (NIH) and World Health Organization standards, BMI between 18.5 and 24.9 is normally specified, while a person with a BMI value of 25 or above is classified as overweight and someone with a BMI value of 30 or above as obese. A person with a BMI below 18.5 is classified as being underweight. However, low BMI values may be healthy in some cases if smoking is not the cause of an eating disorder or disease, while a BMI of 17.5 or less can sometimes be used as a diagnostic criterion for anorexia nervosa (Fahey et al., 2019).

Globally with respect to body fat mass classifying people as weak, normal, overweight and obese, BMI is a cheaper and easily used method compared to subcutaneous fat thickness measurement method (WHO, 2006). Depending on age, gender, maturity, physical activity level and genetic characteristics (Morimoto et al., 2007; Srdic et al., 2012).

Still, to our knowledge, no study results have been published that investigated the use of BMI and skinfold measurements interchangeably in the evaluation of the body composition in exercised and sedentary male and female adults 18 to 21 years old. It may be valuable to know the advantage and disadvantages of BMI and SST in the assessment of body composition of young adults. Thus, this study aimed to determine the correlation between body mass index and sum of skinfold thickness variables in exercised and sedentary male and females aged of 18-21 years.

MATERIALS AND METHODS

Sampling

This study was designed as a correlational research to investigate the statistical relationship between two variables in exercised and sedentary males and females. Data were collected from 611 volunteer young adults including 500 males and 111 females in the age groups of 18, 19, 20 and 21 years. For the purpose of this study, the participants with no health problem were randomly selected and divided into 4 groups as exercised males (EM), sedentary males (SM), exercised females (EF) and sedentary females (SF), during obesity screening.

Data collection

Body height and body weight

Measurements of body weight and height of the participants were taken in standing position with wearing shorts and T-shirt without shoes before breakfast. Body weight was measured in kilograms to the nearest 0.1 kg using a Seca™ digital weighing scale (Seca, Germany). Body height was measured in centimeters to the nearest 0.1 cm using a metal stick of this scale.

Body mass index

BMI was calculated by dividing body weight by the square of the body height in meters (kg/m^2). Underweight was defined as BMI <18.5 kg/m^2; normal weight as BMI ≥18.5 and <25 kg/m^2; overweight as BMI ≥25 and <30 kg/m^2 and obesity as BMI ≥30 kg/m^2. It is a relative body weight measure that highly correlated with direct body fat measurements (Fahey et al., 2019).

Skinfolds and sum of skinfolds thickness (SST)

Holtain brand skinfold caliper, applying 10 g/mm^2 pressure at every angle, was used to measure the skinfold thickness of the body from the right side, while the skinfold measurements and the participants were standing upright. In the measurement of skinfold thickness, the subcutaneous fat layer between the thumb and forefinger and its thickness is pulled up slightly enough to separate from the muscle tissue, and the thickness of the skinfold, which is held by placing the caliper approximately 1 cm from the fingers, is read from the indicator on the caliper for 2-3 seconds. SST consists of the sum of the sub-scapula, triceps, biceps, chest and abdomen, thigh and calf measurements and it was used to assess body fatness for both genders (Lohman et al., 1988). ASRM (Anthropometric standardization reference manual) recommends that same chest skinfold site can be used for both males and females according to Lohman et al. (1998). So, all skinfold measurement was taken by following same procedures.

Statistical analyzes

After presenting the mean and standard deviation (X ± SD) values according to the groups, Pearson's correlation coefficients were calculated due to correlational research design.

RESULTS

While the anthropometric properties of exercised and sedentary male and female young adults according to age groups are shown in Tables 1 and 2, the relationship between body mass index and sum of skinfold thickness between exercised and sedentary male and female participants is presented in Table 3.

Table 1. Anthropometric characteristics of exercised and sedentary male young adults according to age groups.

Variables	Groups	18 years			19 years			20 years			21 years		
		N	M	S.D.	N	M	S.D.	N	M	S.D.	N	M	S.D.
Body height (cm)	Exercised	16	170.94	7.62	23	173.74	7.09	35	173.40	6.80	56	173.13	6.13
	Sedentary	44	171.23	7.33	64	172.75	6.48	85	172.45	5.83	177	173.49	5.87
	Total	60	171.15	7.34	87	173.01	6.62	120	172.73	6.11	233	173.40	5.92
Body weight (kg)	Exercised	16	60.63	5.01	23	64.09	7.84	35	65.23	8.59	56	64.32	6.49
	Sedentary	44	61.11	7.20	64	64.23	6.43	85	62.86	6.86	177	64.35	6.45
	Total	60	60.98	6.65	87	64.20	6.78	120	63.55	7.45	233	64.34	6.45
Body Mass Index (BMI)	Exercised	16	20.85	2.54	23	21.22	2.14	35	21.66	2.31	56	21.47	2.02
	Sedentary	44	20.83	2.02	64	21.52	1.75	85	21.12	1.91	177	21.38	1.93
	Total	60	20.83	2.15	87	21.44	1.85	120	21.28	2.04	233	21.40	1.94
Biceps skinfold (mm)	Exercised	16	3.28	0.97	23	3.68	0.61	35	3.57	0.97	56	3.37	0.60
	Sedentary	44	3.34	0.78	64	3.23	0.56	85	3.36	1.21	177	3.34	0.77
	Total	60	3.33	0.83	87	3.35	0.61	120	3.42	1.15	233	3.35	0.73
Triceps skinfold (mm)	Exercised	16	5.70	1.17	23	7.17	2.29	35	7.81	3.18	56	6.64	1.99
	Sedentary	44	6.15	1.86	64	6.32	2.45	85	6.06	1.98	177	6.02	1.75
	Total	60	6.03	1.71	87	6.54	2.43	120	6.57	2.51	233	6.17	1.82
Sub-scapula skinfold (mm)	Exercised	16	7.25	1.29	23	8.37	2.14	35	9.40	1.85	56	8.65	1.89
	Sedentary	44	7.31	1.98	64	7.70	1.66	85	7.99	1.90	177	8.49	1.80
	Total	60	7.29	1.81	87	7.87	1.81	120	8.40	1.98	233	8.52	1.82
Abdominal skinfold (mm)	Exercised	16	8.17	2.89	23	11.42	6.31	35	12.21	5.26	56	11.22	5.29
	Sedentary	44	8.31	3.99	64	8.60	3.53	85	9.14	3.88	177	8.97	3.25
	Total	60	8.27	3.71	87	9.34	4.57	120	10.03	4.53	233	9.51	3.94
Chest skinfold (mm)	Exercised	16	5.02	3.66	23	5.21	2.17	35	5.31	1.82	56	4.96	1.59
	Sedentary	44	4.42	1.52	64	4.30	0.91	85	4.54	1.56	177	4.63	2.54
	Total	60	4.58	2.27	87	4.54	1.41	120	4.76	1.67	233	4.71	2.35
Thigh skinfold (mm)	Exercised	16	8.81	2.74	23	10.56	3.84	35	11.05	4.25	56	9.86	3.96
	Sedentary	44	8.84	3.03	64	8.33	2.72	85	8.63	3.46	177	9.22	5.19
	Total	60	8.83	2.93	87	8.92	3.19	120	9.33	3.85	233	9.37	4.92
Calf skinfold (mm)	Exercised	16	6.92	2.40	23	7.90	2.70	35	7.75	4.28	56	6.83	2.61
	Sedentary	44	6.33	2.40	64	7.05	4.51	85	6.10	2.29	177	6.06	2.19
	Total	60	6.49	2.39	87	7.27	4.11	120	6.58	3.09	233	6.24	2.32
Sum of skinfold thickness (mm)	Exercised	16	45.15	11.03	23	54.31	17.87	35	57.10	18.01	56	51.53	15.18
	Sedentary	44	44.70	12.83	64	45.51	12.85	85	45.81	13.00	177	46.74	12.25
	Total	60	44.82	12.28	87	47.84	14.76	120	49.10	15.45	233	47.89	13.14

Comparison of BMI averages between exercised and sedentary males is presented in Figure 1, while comparison of BMI averages between exercised and sedentary females by age groups is shown in Figure 3. On the other hand, comparison of SST averages between exercised and sedentary males is presented in Figure 2, while comparison of SST averages between exercised and sedentary females by age groups is shown in Figure 4.

Comparison of the relationship between BMI and SST

Table 2. Anthropometric characteristics of exercised and sedentary female young adults according to age groups.

Variables	Groups	18 years			19 years			20 years			21 years		
		N	M	S.D.	N	M	S.D.	N	M	S.D.	N	M	S.D.
Body height (cm)	Exercised	9	165.44	5.05	16	165.56	5.49	14	162.36	5.73	17	162.47	7.15
	Sedentary	8	164.25	6.63	11	160.82	5.60	12	163.17	7.49	24	163.13	4.70
	Total	17	164.88	5.69	27	163.63	5.92	26	162.73	6.48	41	162.85	5.77
Body weight (kg)	Exercised	9	50.89	6.17	16	54.63	5.99	14	52.21	5.75	17	52.65	5.82
	Sedentary	8	49.88	5.22	11	51.45	5.07	12	52.00	4.05	24	52.00	7.31
	Total	17	50.41	5.59	27	53.33	5.75	26	52.12	4.94	41	52.27	6.66
Body Mass Index (BMI)	Exercised	9	18.62	2.45	16	19.91	1.81	14	19.82	2.05	17	19.95	1.95
	Sedentary	8	18.48	1.49	11	19.89	1.62	12	19.61	2.01	24	19.51	2.33
	Total	17	18.55	1.99	27	19.90	1.70	26	19.72	1.99	41	19.69	2.17
Biceps skinfold (mm)	Exercised	9	6.22	2.53	16	6.86	1.90	14	6.30	2.44	17	11.69	15.58
	Sedentary	8	5.69	1.02	11	6.51	1.91	12	5.90	1.82	24	5.52	2.49
	Total	17	5.97	1.93	27	6.72	1.88	26	6.12	2.14	41	8.08	10.49
Triceps skinfold (mm)	Exercised	9	13.59	3.70	16	13.70	3.91	14	12.74	3.60	17	12.68	3.62
	Sedentary	8	12.70	3.45	11	11.79	2.93	12	12.38	3.55	24	11.78	4.03
	Total	17	13.17	3.50	27	12.92	3.61	26	12.58	3.51	41	12.15	3.84
Sub-scapula skinfold (mm)	Exercised	9	11.08	3.12	16	13.34	3.72	14	11.49	2.86	17	12.16	3.34
	Sedentary	8	12.26	2.24	11	13.57	6.27	12	12.49	4.05	24	11.58	2.90
	Total	17	11.64	2.73	27	13.43	4.81	26	11.95	3.43	41	11.82	3.06
Abdominal skinfold (mm)	Exercised	9	18.08	7.62	16	25.06	3.53	14	22.08	5.85	17	25.05	6.48
	Sedentary	8	18.26	6.07	11	23.14	7.25	12	23.43	6.99	24	20.44	5.87
	Total	17	18.16	6.72	27	24.28	5.33	26	22.70	6.31	41	22.35	6.47
Chest skinfold (mm)	Exercised	9	10.21	4.27	16	11.68	2.85	14	9.86	2.75	17	10.24	3.65
	Sedentary	8	11.33	3.23	11	13.04	4.42	12	12.03	4.34	24	10.52	3.43
	Total	17	10.74	3.74	27	12.23	3.56	26	10.86	3.67	41	10.40	3.48
Thigh skinfold (mm)	Exercised	9	21.84	4.72	16	22.96	5.82	14	22.47	6.23	17	24.11	4.77
	Sedentary	8	21.08	4.58	11	20.95	6.83	12	21.48	4.59	24	20.25	4.79
	Total	17	21.48	4.52	27	22.14	6.20	26	22.01	5.45	41	21.85	5.10
Calf skinfold (mm)	Exercised	9	15.37	4.64	16	16.89	4.85	14	16.34	4.72	17	15.78	4.39
	Sedentary	8	13.60	3.45	11	17.67	5.33	12	14.11	4.10	24	12.70	5.41
	Total	17	14.54	4.10	27	17.21	4.97	26	15.31	4.50	41	13.98	5.18
Sum of skinfold thickness (mm)	Exercised	9	96.39	23.25	16	110.49	21.45	14	101.28	23.83	17	111.71	23.88
	Sedentary	8	94.91	18.94	11	106.66	24.42	12	101.83	24.70	24	92.31	21.20
	Total	17	95.69	20.68	27	108.93	22.32	26	101.53	23.75	41	100.35	24.09

in exercised and sedentary males by age groups is shown in Figure 5, while the relationship between BMI and SST in exercised and sedentary females by age groups is shown in Figure 6.

Significant correlations were observed between BMI and SST in EM ($p < 0.01$; $r = .442$), SM ($p < 0.01$; $r = .449$), EF ($p < 0.01$; $r = .680$) and SF ($p < 0.01$; $r = .423$). Highest significant correlations were observed between BMI and sub-scapula skinfold ($p < 0.01$, $r = .504$) and between SST and thigh skinfold ($p < 0.01$, $r = .909$) in EM

Table 3. Relationship between BMI and SST of exercised and sedentary male and females to age groups (Pearson correlation coefficient).

Gender	Groups	Age groups			
		18 years	19 years	20 years	21 years
Males	Exercised	.540*	.494*	.221	.531**
	Sedentary	.417**	.444**	.448**	.462**
Females	Exercised	.727*	.802**	.848**	.400
	Sedentary	.514	751**	.524	.256

* There is a significant difference between BMI and SST at the level of 0.05.
** There is a significant difference between BMI and SST at the level of 0.01.

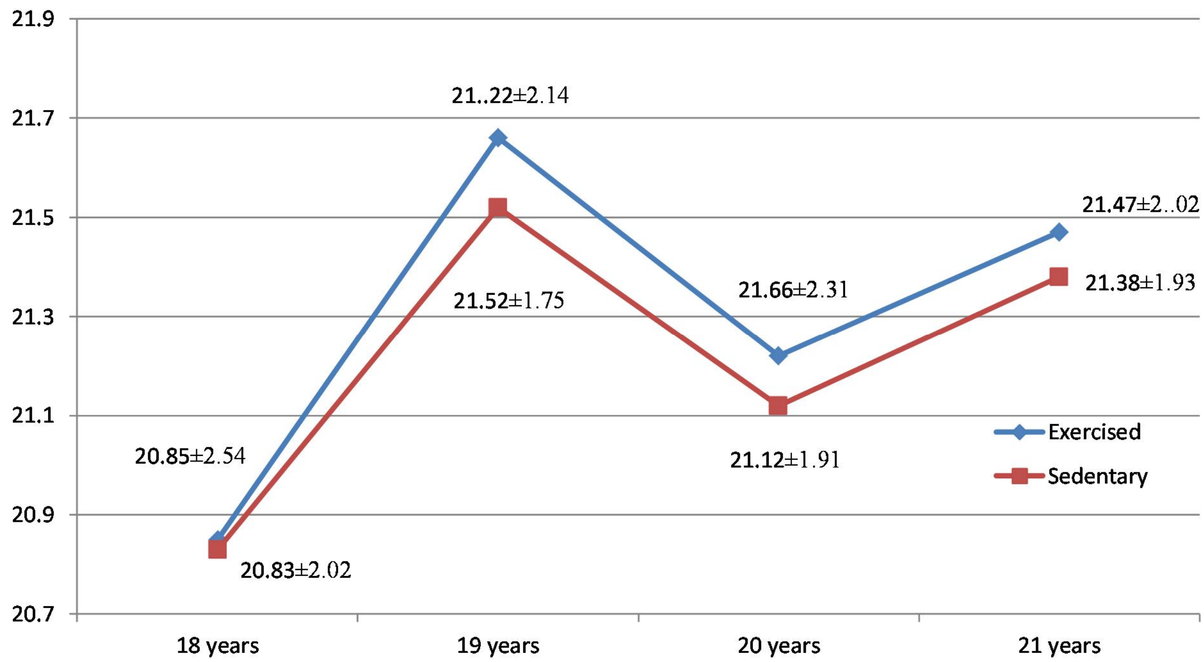

Figure 1. BMI averages of exercised and sedentary males by age groups.

while there were highest correlations between BMI and sub-scapula skinfold (p < 0.01, r = .447) and between SST and abdomen skinfold (p < 0.01, r = .856) in SM.

Highest significant correlations were observed between BMI and sub-scapula skinfold (p < 0.01, r = .692) and between SST and thigh skinfold (p < 0.01, r = .806) in EF while there were highest correlations between BMI and triceps skinfold (p < 0.01, r = .444) and between SST and abdomen skinfold (p < 0.01, r = .844) in SF.

DISCUSSION

Body mass index (BMI) can be useful in determining the health risks of body weight when complex methods cannot be used. Although it is more accurate than height-weight tables, body mass index is also based on the concept that weight should be proportional. BMI is also a measure of relative body weight correlating highly with more direct measures of body fat percentage (Fahey et al., 2019). Due to lack of sufficient evidence on this subject it is difficult to explain the interrelationship between BMI and SST in the evaluation of body composition of exercised and sedentary young adults in Turkey.

This study showed that the highest mean BMI in EM was 21.66, while this value for SM was 21.52 (Figure 1). Again, the highest SST value for EM is 57.10 mm, while the highest SST of SM was 46.74 mm (Figure 2). In addition, the highest mean BMI in EF was 19.95, while the highest BMI in SF was 19.89 (Figure 3). Again, the highest SST value for EF is 11.71 mm, while the highest SST of SF was 106.66 mm (Figure 4). In general, males appear to have twice the average SST of females.

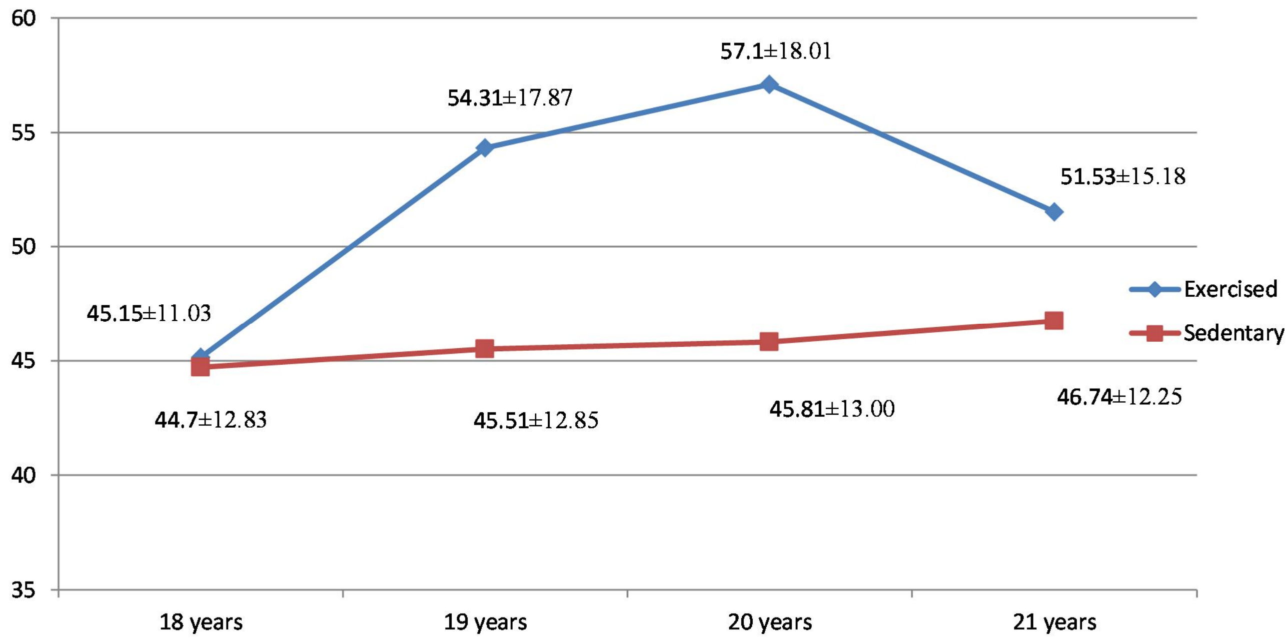

Figure 2. SST averages of exercised and sedentary males by age groups.

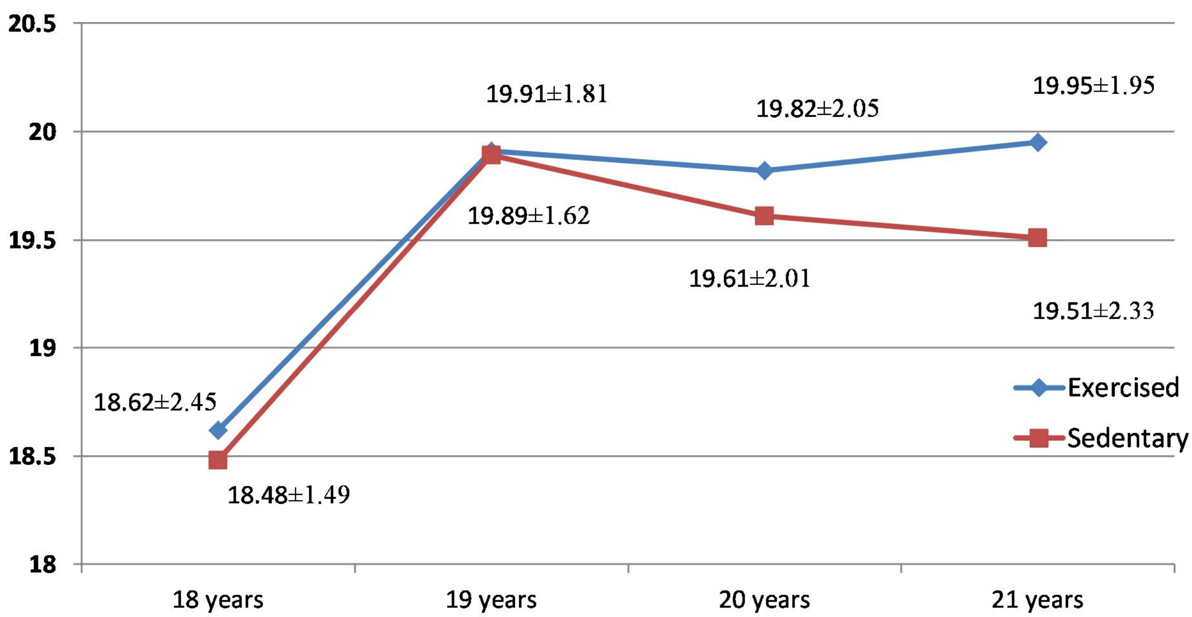

Figure 3. BMI averages of exercised and sedentary females by age groups.

Marques-Vidal et al. (2008) assessed the body composition of 2494 boys and 2519 girls aged 10 to 18 years by bioelectrical impedance using a bipolar handheld device. Similar to our study, they found that percent body fat levels were higher in girls and decreased with age in both genders. They also stated that using body fat percentage obtained from skinfold measurements reveal similar to results of bioelectrical impedance. Similar to our study, the results obtained by field methods show that the association of the results with skinfold measurements as indicators of subcutaneous fat thickness, may be used instead of direct laboratory measurements to understand the efficiency of a field method.

On the other hand, the interrelationship between BMI and SST was increasing from 18 to 20 years of age

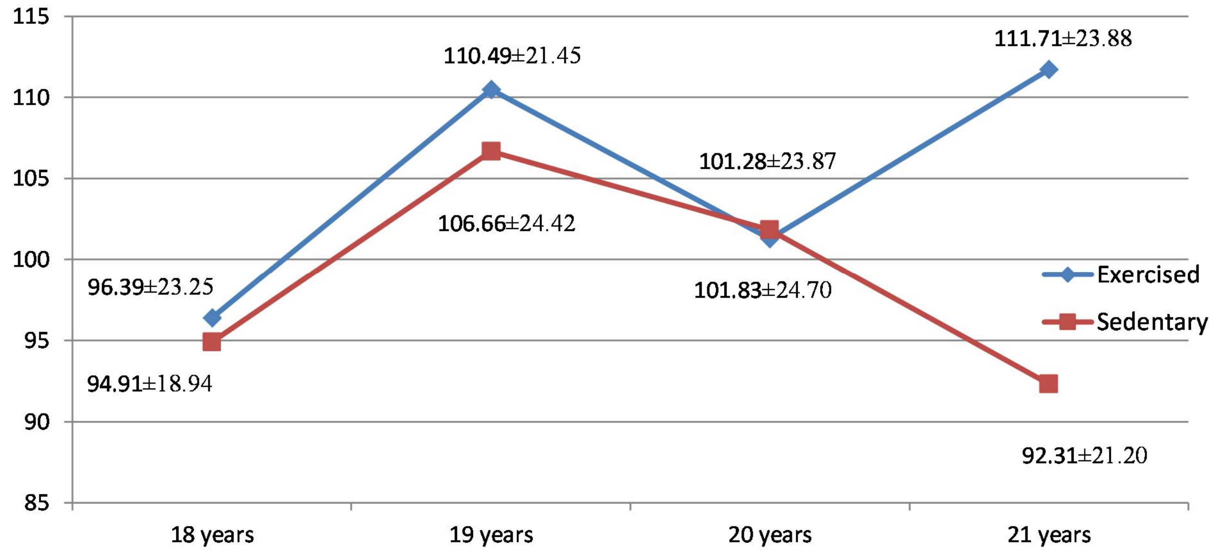

Figure 4. SST averages of exercised and sedentary females by age groups.

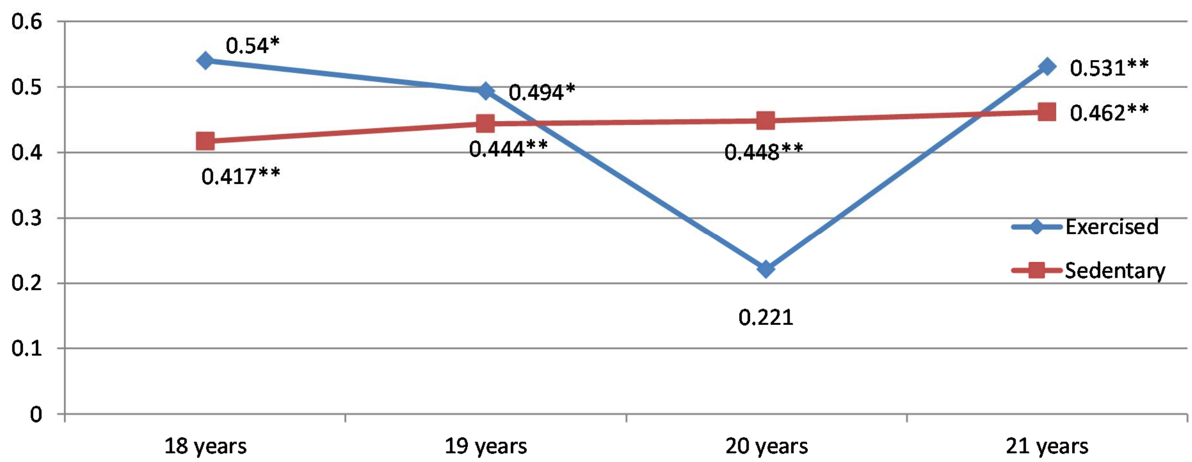

Figure 5. The relationship between BMI and SST of exercised and sedentary males according to age groups. * There is a significant difference between BMI and SST at the level of 0.05. ** There is a significant difference between BMI and SST at the level of 0.01.

groups and was decreasing by 20 years while there was increasing relationships by 21 years group in EM, ($p < 0.01$). In SM, there was significant and slightly increasing relationship between BMI and SST from age 18 to 21. These significant relationships were found in 18 years ($r = .54$, $p < .01$), 19 years ($r = .417$, $p < .01$), 20 years ($r = .531$, $p < .01$) and 21 years ($r = .462$, $p < .01$). The relationship between BMI and SST in EF was increasing up to 20 years of age in females and was decreasing by 21 years age group ($p < 0.01$). In SF, the relationship between BMI and SST was only significant in 19 years and then tends to decrease as statistically insignificant in other age groups (Table 3). The results of current research were in agreement in the results reported by Fahey et al. (2019) demonstrating that older adults tend to have more body fat than younger adults for an equivalent BMI.

The significant relationship between BMI and SST in females was higher than in males depending on exercise participation. The differences between males and females in our study can be explained in the best way with sexual dimorphism. It causes the man to have larger body size with high masculinity than the woman. Adult male is 7% taller than female (Kirchengast, 2010). Naturally, females have more body fat than males among healthy adults at a given BMI. Also physically active people or athletes exercising regular weight training have more muscle mass than those who train less with similar

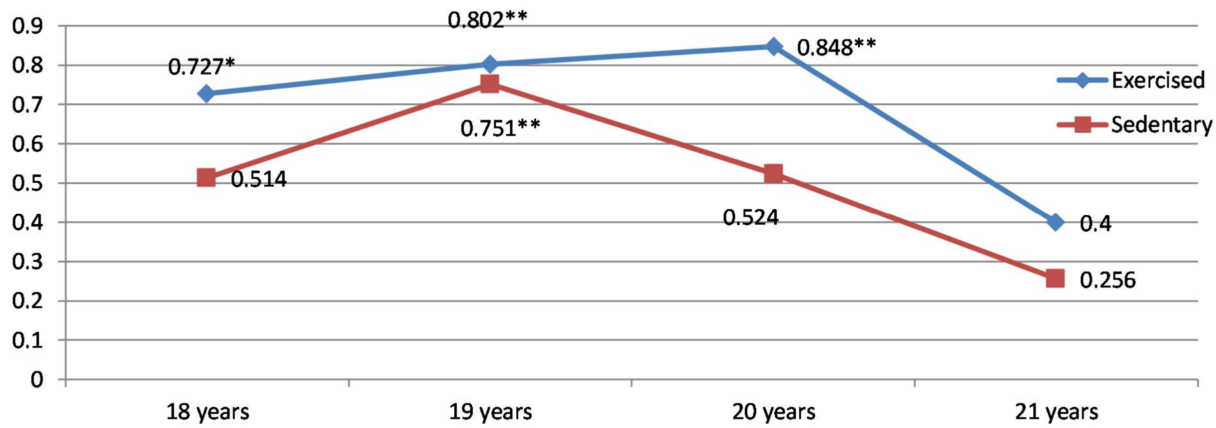

Figure 6. The relationship between BMI and SST of exercised and sedentary females according to age groups. * There is a significant difference between BMI and SST at the level of 0.05. ** There is a significant difference between BMI and SST at the level of 0.01.

body height and body weight . When evaluating the body composition of an athlete, an intense weight trainer or a short person, it does not seem appropriate to use BMI as a priority to assess whether the current body weight is ideal or healthy (Fahey et al., 2019). The results of our study partially were in disagreement with the results reported by Fahey et al. (2019). Clearly current research indicated that the correlations between BMI and SST were highest for exercised females, second highest for sedentary males and the lowest for exercised males and sedentary females. Thus, BMI value of exercised females can be moderately used as a body fat indicator compared to other groups due to higher and significant correlation between BMI and SST (r = .680, p < 0.01). Moreover, Sentinelli et al. (2015) showed that women participating regularly Nordic walking have decreased body weight and BMI values compared to sedentary. Similarly, Sevimli and Ozoruç (2018) determined the mean BMI value of 965 volunteers aged 14-30 including exercised and sedentary females and they reported that BMI values of the active group were lower than those of sedentary individuals. Also, Sivrikaya et al. (2019) determined level of association between body mass index (BMI) and total skinfold thickness (TST) in physically active and sedentary boys and girls aged between 8 and 14 years. They stated that the relationship between BMI and TST varies due to age, gender, and habitual physical activity. They concluded that BMI and TST measurements cannot be used alternately in the evaluation of body composition of active and sedentary boys and girls.

In general, there are important differences in the measurement of skinfold thickness (WHO, 2006). Measurement errors increase with increasing body fat level (Marks et al., 1989). Although BMI estimates less body fat than other methods (Bray et al., 2002), the findings of another study report that levels of various risk factors do not show a stronger relationship with BMI than skinfold thicknesses. Generally, BMI cannot differentiate the body fat and lean mass, and has limitations as an indicator of body fat percentage (Prentice and Jebb, 2001).

In a study investigating the relationship between obesity and anthropometric measurements in adolescents, BMI was reported to be significantly associated with SST (r = .40, p < 0.05) when the gender variable is not considered (Bulduk et al., 2015). Moreover, it was reported that there was a moderate correlation between BMI and body fat ratio (r = .0.7) in many studies (Bray et al., 2002; Daniels et al., 1997; Kerruish et al., 2002).

There was significant correlation between mean BMI and SST in EM (r = .425, p < 0.01). The highest correlation was between BMI and sub-scapula skinfold (r = 504, p < 0.01) while this correlation was observed between SST and thigh skinfold in EM (r = .909, p < 0.01). In SM, there was significant correlation between mean BMI and SST in SM (r = .449, p < 0.01). The highest correlation was observed between BMI and triceps skinfold in SM (r = .447, p < 0.01) while this correlation (r = .856, p < 0.01) was observed between SST and abdomen skinfold in SM (Figure 5). There was significant correlation between mean BMI and SST in EF (r = .680, p < 0.01). The highest correlation was between BMI and sub-scapula skinfold (r = .692, p < 0.01) while this correlation was observed between SST and thigh skinfold in EF (r = .806, p < 0.01). In SF, there was significant correlation between mean BMI and SST in SF (r = .423, p < 0.01). The highest correlation was observed between BMI and triceps skinfold in SF (r = .444, p < 0.01) while this correlation was observed between SST and triceps skinfold (r = .844, p < 0.01) in SF (Table 4, Figure 6). BMI is only an indirect indicator of body obesity, as it does not differentiate between fat weight and lean body weight, and therefore will not correctly classify all individuals their body fatness. In a study, Freedman et al. (2015)

Table 4. Pearson correlation coefficients among BMI, skinfolds and SST of exercised and sedentary male and females with regardless of age groups.

Variables	Exercised males		Sedentary males		Exercised females		Sedentary females	
	BMI	SST	BMI	SST	BMI	SST	BMI	SST
BMI	1	.425**	1	.449**	1	.680**	1	.423**
SST	.425**	1	.449**	1	.680**	1	.423**	1
Biceps skinfold	.442**	.777**	.366**	.564**	.017	.474**	.291*	.736**
Triceps skinfold	.398**	.858**	.387**	.796**	.574**	.687**	.444**	.844**
Sub-scapula skinfold	.504**	.789**	.447**	.711**	.692**	.672**	.307*	.637**
Abdomen skinfold	.318**	.864**	.398**	.856**	.632**	.727**	.400**	.784**
Chest skinfold	.449**	.730**	.236**	.496**	.476**	.599**	.105	.689**
Thigh skinfold	.352**	.909**	.252**	.750**	.630**	.806**	.193	.648**
Calf skinfold	.200*	.763**	.284**	.714**	.519**	.753**	.365**	.833**

* There is a significant difference between the two variables at the level of 0.05.
** There is a significant difference between the two variables at the level of 0.01.

investigated the accuracy of Slaughter skinfold thickness with the body fat percentage levels calculated from dual energy X-ray absorptiometry (PBFDXA) on 7599 boys and girls aged 8 to 19. They found that Slaughter skinfold measurements underestimated significantly DXA's average body fat percentage by 4 percent for boys and 6 percent for girls. The relationship between BMI and actual body fat percentage were affected by factors including muscle mass, age, gender body weight and height affect. It should be recommended that more sophisticated laboratory methods should be used to keep track of increases in BMI over time and changes in fat loss in age groups when BMI and SST are not valid and reliable for estimating body fat.

In conclusion, Pearson correlation coefficient analyzes showed that sub-scapula, abdomen and, thigh skinfolds were significantly correlated with BMI and SST in exercised and sedentary males while sub-scapula, triceps and thigh skinfolds correlated strongly with BMI and SST in exercised and sedentary females.

The significant relationship between BMI and SST has increased slightly in sedentary males from 18 to 21 years of age, while it decreases slightly from 18 to 19 years of age in exercising males, while it increases to a significant level at 21 years of age following a sharp decline in 20 years of age. The reason for this sharp decrease can be thought to be due to the increase in body weight caused by the increase in muscle mass in males. The significant relationship between BMI and SST decreases after 20 years of age in exercised females, and turns into a downward trend in sedentary females after 19 years of age. In contrast to males, the significant relationship between BMI and SST is higher in exercised females. It can be stated that the relationship between BMI and SST varies depending on the body height and body weight, gender and participation in physical activity. In the absence of valid and complex method, the body fat percentage can be strongly estimated by BMI in exercised females than EM, SM and SF counterparts. In other side, SST were strongly correlated with thigh skinfold in EM ($r = .909$; $p < 0.01$), with abdomen skinfold in SM ($r = .856$; $p < 0.01$), with thigh skinfold in EF ($r = .806$; $p < 0.01$) and by triceps skinfold in SF ($r = .844$; $p < 0.01$). In the evaluation of the body composition, it is recommended that the validity of BMI and sum of skinfolds thickness be correlated with DXA / DEXA (Dual-energy X-ray absorptiometry) measurements used as the gold method.

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