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Comparison of Muscle Mass between Obesity Classes by Different Formulas in Diabetes Mellitus

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ABSTRACT

Objective: *Sarcopenia is a risk for type 2 diabetes mellitus (DM) patients, however, to diagnose sarcopenia is difficult in these patients since they are generally obese. There is more than one method used to diagnose sarcopenia. The present study aimed to compare different formulas that evaluate muscle mass among age and BMI groups in overweight and obese DM patients.* ***Methods:*** *The study included DM over the age of 18 years with BMI ≥ 25 kg/m². In all patients, body weight, total appendicular muscle mass (ASM), total muscle mass, and total fat mass were measured by bioimpedance method. Thereafter, skeletal muscle index was calculated dividing ASM by height (kg/m²); appendicular muscle mass percentage (%) was calculated dividing ASM by body weight; total muscle mass index (kg/m²) was calculated dividing total muscle mass by body height (kg/m²); and total muscle percentage (%) was calculated dividing total muscle mass by body weight.* ***Results:*** *Of the 486 DM patients enrolled in the study, the mean age was 54.47 ± 8.82 years, and the mean BMI was 38.58 ± 6.25 kg/m². Skeletal muscle index was 8.16 ± 0.95 kg/m² in overweight, 9.23 ± 1.04 kg/m² in class-1 obese, 9.95 ± 1.05 kg/m² in class-2 obese, and 11.59 ± 1.58 kg/m² in class-3 obese (p<0.001). Total muscle percentage was 66.18 ± 6.63% in overweight, 58.89 ± 5.77% in class-1 obese, 54.35 ± 4.51% in class-2 obese, and 51.19 ± 3.92% in class-3 obese (p<0.001).* ***Conclusions:*** *Total muscle percentage may be useful in assessing muscle mass in obese subjects like DM patients.*

Keywords: Sarcopenia, Obesity, Skeletal muscle, Muscle weakness, Type 2 diabetes mellitus

INTRODUCTION

Sarcopenic obesity, which is defined as decreased muscle mass in obese subjects, is more prevalent in type 2 Diabetes mellitus (DM) patients [1,2]. According to the body mass index (BMI) used in the World Health Organization's obesity classification, 25.0-29.99 kg/m² is defined as overweight, 30.0-34.99 kg/m² is defined as class 1 obesity, 35.0-39.99 kg/m² is defined as class 2 obesity, and ≥ 40 kg/m² is defined as class 3 obesity [3]. Although many different indexes and ratios have been used to evaluate body muscle mass, there is no method agreed for the diagnosis [4,5]. One of these formulas is the ratio of total appendicular muscle mass (ASM) to the body height in square meter, whereas the other one is the ratio of total ASM to body weight [1,2,6-10]. Moreover, the ratio of total muscle mass to the height in square meter or to the body weight are among the formulas [1,2,6-10]. Since a strong correlation was observed between BMI and muscle mass, making the diagnosis of sarcopenia difficult in obese patients [5,11,12]. A study determined that appendicular muscle index used to diagnose sarcopenia may hinder decreased muscle mass when used in overweight and obese subjects although it can be used in normal-weight subjects [12]. The present study aimed to compare muscle mass among age and BMI groups in type 2 diabetes mellitus patients with a BMI ≥ 25 kg/m² by means of different formulas used in the diagnosis of sarcopenia.

PATIENTS AND METHODS

Data derived from "prevalence of sarcopenia in the type 2 diabetes mellitus project", which was type 2 diabetes mellitus patients over the age of 18 years, who was presented at the Obesity Clinic of Kartal Dr. Lutfi Kirdar Training and Research Hospital between March 2015 and June 2015 and who were overweight or obese according to the BMI classes, were enrolled in the study.

Bioimpedance analysis (BIA) (TANITA-48M, TANITA, Tokyo, Japan) and HbA1c value (Bio-Rad variant II, Bio-Rad, Richmond, CA, USA) were evaluated in each patient after the 12-hour fasting period. While performing BIA, body weight, height, total muscle mass, total appendicular muscle mass, and body fat mass measurements were also recorded. Using these measurements, body mass index (BMI) was calculated as the ratio of body weight in kilograms to the height in square meters (kg/m^2). The formulas of muscle analyses are summarized in Table 1.

Table 1 The formulas of the muscle analyses

Variables	Formula
Skeletal muscle index (kg/m^2)	Total appendicular muscle mass/height^2
Total muscle index (kg/m^2)	Total muscle mass/height^2
Appendicular muscle percentage (%)	(Total appendicular muscle mass/weight) × 100
Total muscle percentage (%)	(Total muscle mass/weight) × 100
ASM/BMI ratio ($kg/kg/m^2$)	Total appendicular muscle mass/BMI
Fat/muscle ratio (%)	(Total fat mass/total muscle mass) × 100
ASM: Total appendicular muscle mass; BMI: Body mass index	

Age, BMI, and HbA1c are the independent variables, whereas total appendicular muscle mass, skeletal muscle index, appendicular muscle percentage, ASM/BMI ratio, total muscle index, total muscle percentage, and fat/muscle ratio are the dependent variables of the study. Given that muscle mass begins decreasing by 1-2% each year from the age of 50 years, the study evaluated the difference between the patients aged under and over 50 years [5,13]. While evaluating blood glucose regulation, the cut-off value for HbA1c was taken as 7%; HbA1c <7% was defined as good blood glucose regulation, HbA1c ≥ 7% was defined as poor blood glucose regulation [14].

Patients with type 1 diabetes mellitus, chronic renal failure, chronic liver disease, and documented neuromuscular disease, as well as pregnant women, were not included in the study.

Statistical Analysis

Statistical analysis of data was performed using SPSS version 22 program. Descriptive statistics were evaluated as frequency, mean ± standard deviation and percentage. In addition, student t-test was used for continuous variables, Pearson correlation analysis was performed, and the difference between the groups was evaluated by ANOVA test. The study was approved by the Ethics Committee of Kartal Dr. Lutfi Kirdar Training and Research Hospital (Protocol No: 89513307/1009/510). Informed consent is not necessary due to the retrospective nature of this study. The procedures followed were in accordance with the ethical standards of the committee and the Helsinki Declaration.

RESULTS

The study comprised a total of 486 type 2 diabetes mellitus patients, of whom 400 (82.30%) were female. Of the participants, the mean age was 54.47 ± 8.82 years, the mean BMI was 38.58 ± 6.25 kg/m^2 and the mean HbA1c was 7.38 ± 1.78%.

To make comparison according to age, the participants were divided into 2 age groups as <50 years and ≥ 50 years. No significant difference was determined between the 2 groups in terms of mean HbA1c values (p=0.085). All of the formulas, except skeletal muscle index and appendicular muscle percentage, revealed a decrease. Bioimpedance measurements of the participants according to the age group are summarized in Table 2.

Table 2 Bioimpedance measurements according to the age groups

Variables	<50 years		≥ 50 years		p-value*
	n	Mean ± SD	n	Mean ± SD	
BMI (kg/m^2)	123	38.59 ± 7.37	363	38.58 ± 5.84	0.995
Total appendicular muscle mass (kg)	123	28.03 ± 6.65	363	25.65 ± 4.75	<0.001
Skeletal muscle index (kg/m^2)	123	10.43 ± 1.92	363	10.27 ± 1.63	0.410
Appendicular muscle percentage (%)	123	27.32 ± 3.78	363	26.78 ± 2.98	0.148

ASM/BMI ratio	123	0.74 ± 0.16	363	0.67 ± 0.12	<0.001
Total muscle index (kg/m²)	123	21.50 ± 2.79	363	20.74 ± 2.42	0.004
Total muscle percentage (%)	123	56.69 ± 7.36	363	54.34 ± 5.96	<0.001
Total fat/muscle ratio (%)	123	71.39 ± 21.04	363	77.30 ± 17.42	0.002
ASM: Total appendicular muscle mass; BMI: Body mass index; *Student t Test					

The participants were divided into 4 groups according to the BMI value as overweight, class 1 obesity, class 2 obesity, and class 3 obesity. No difference was determined between the groups in terms of mean HbA1c values; however, the mean age was higher in class 2 obesity group as compared to the other groups (p=0.456 and p=0.024, respectively). Bioimpedance measurements of the participants according to the BMI group are summarized in Table 3.

Table 3 Bioimpedance measurements according to the obesity classes

Variables	Overweight		Class 1 obesity		Class 2 obesity		Class 3 obesity		p*
	n	Mean ± SD	n	Mean ± SD	n	Mean ± SD	n	Mean ± SD	
BMI (kg/m²)	37	27.71 ± 1.41	100	32.74 ± 1.39	157	37.31 ± 1.41	192	44.77 ± 3.97	<0.001
Total appendicular muscle mass (kg)	37	21.9 ± 4.21	100	24.41 ± 4.78	157	25.45 ± 4.84	192	28.69 ± 5.26	<0.001
Skeletal muscle index (kg/m²)	37	8.16 ± 0.95	100	9.23 ± 1.04	157	9.95 ± 1.05	192	11.59 ± 1.58	<0.001
Appendicular muscle percentage (%)	37	29.48 ± 3.20	100	28.22 ± 3.28	157	26.69 ± 2.91	192	25.93 ± 2.92	<0.001
ASM/BMI ratio	37	0.79 ± 0.14	100	0.74 ± 0.15	157	0.68 ± 0.13	192	0.64 ± 0.10	<0.001
Total muscle index (kg/m²)	37	18.34 ± 2.06	100	19.25 ± 1.74	157	20.26 ± 1.61	192	22.87 ± 2.24	<0.001
Total muscle percentage (%)	37	66.18 ± 6.63	100	58.89 ± 5.77	157	54.35 ± 4.51	192	51.19 ± 3.92	<0.001
Total fat/muscle ratio (%)	37	46.99 ± 14.16	100	64.12 ± 15.21	157	76.52 ± 13.49	192	86.86 ± 14.60	<0.001
ASM, Total appendicular muscle mass; BMI, Body mass index; *ANOVA test									

Comparing the ASM/BMI values among obesity classes, no difference was determined between overweight and class 1 obesity group, whereas a significant difference was determined between class 1 and class 2 obesity groups and between class 2 and class 3 obesity groups (p=0.113, p<0.001 and p=0.002, respectively). Muscle analyses of the obesity classes are demonstrated in Figures 1 and 2.

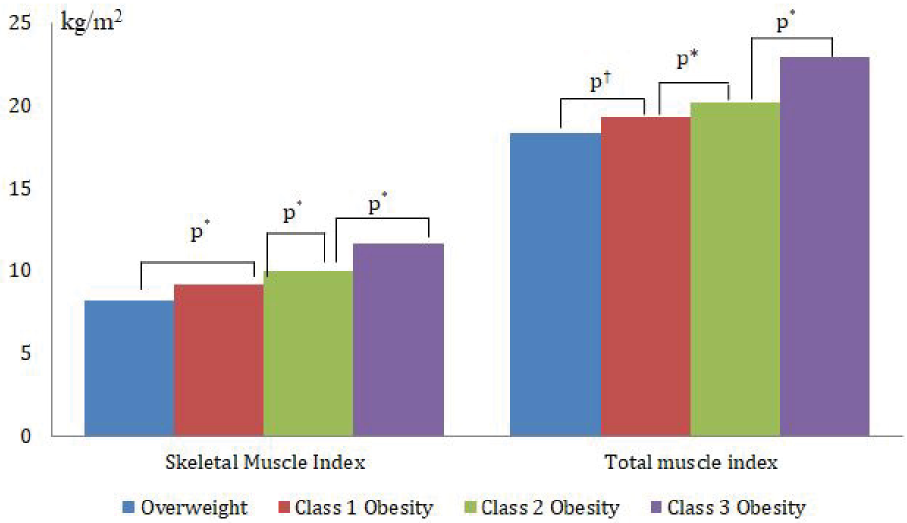

Figure 1 Muscle measurement indexes, p*<0.001 and p†=0.02

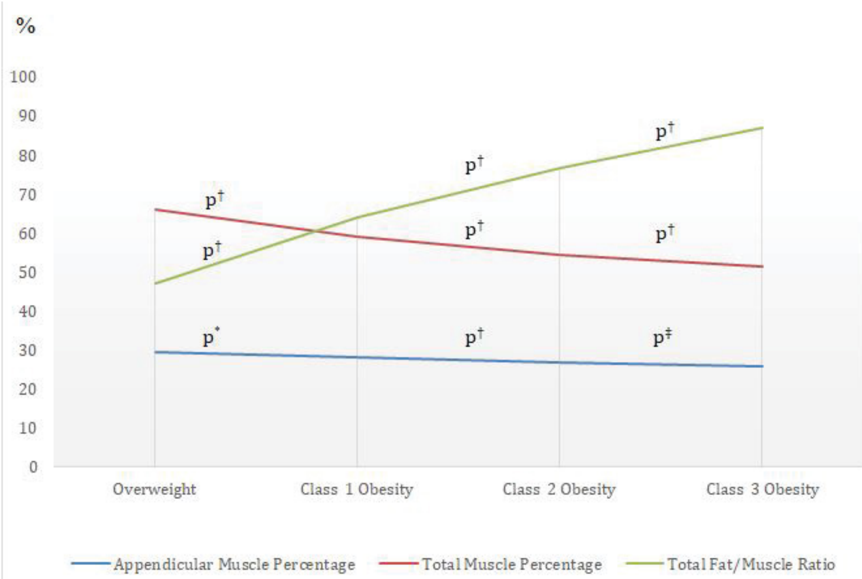

Figure 2 Muscle measurement percentages, p*=0.05; p†<0.001; p‡=0.02

The patients were divided into 2 groups according to the HbA1c levels as <7% and >7%; no significant difference was determined between the groups in terms of skeletal muscle index, appendicular muscle percentage and total muscle index (p>0.05). Nevertheless, total muscle percentage was 54.30 ± 5.87 in the group with good glycemic control and 55.60 ± 6.89 in the group with poor glycemic control, and ASM/BMI ratio was 0.67 ± 0.12 in the group with good glycemic control and 0.70 ± 0.15 in the group with poor glycemic control (p=0.026 and p=0.018, respectively).

DISCUSSION

Sarcopenic obesity, which is defined as the togetherness of decreased muscle mass and obesity, is more prevalent in DM patients versus non-diabetic subjects [2,15]. Nevertheless, there is no definite formula agreed among the indexes used in diagnosing sarcopenic obesity, and it is reported that the evaluation of muscle mass is difficult particularly in obese subjects [4,5,12]. The present study aimed to compare the muscle mass measured by different formulas among age and BMI groups in overweight and obese type 2 diabetes mellitus patients.

In the present study, a significant decrease was determined in terms of ASM, total muscle index and total muscle percentage in the participants aged ≥ 50 years. No difference was determined between the 2 age groups in terms of skeletal muscle index and appendicular muscle percentage. Muscle mass decreases by approximately 1-2% per year after the age of 50 years, and it was determined that sarcopenia and visceral adipose tissue may have a synergistic effect on metabolic disorders [5,13]. Skeletal muscle index and accordingly appendicular muscle mass are frequently used to evaluate sarcopenia, which is a significant risk factor for frailty syndrome that influences the duration and quality of life in elder subjects [2,12]. Although total lean body mass decreases beginning from mid-forties, the ratio of total lean body mass to body weight begins to decrease earlier, and consequently, sarcopenia may develop in a young population in the third decade of life [10]. Considering the results of the present study, it is thought that using total muscle index and total muscle percentage would be more appropriate in evaluating muscle mass in old and obese subjects.

In the present study, skeletal muscle index showed a significant increase from overweight to class 3 obesity group, whereas a significant decrease was determined in the appendicular muscle percentage particularly in obese subjects. Evaluation of muscle mass becomes more difficult in obese subjects due to increased total body fat mass [1,2,6,10,15,16]. The results of the studies evaluating the muscle mass in diabetic patients by skeletal muscle index are debatable [2,12]. Some studies determined low skeletal muscle index in DM patients, whereas some studies failed to determine such a relationship [2,12]. On the other hand, while there are studies demonstrating that sarcopenic obesity is more prevalent in the patients with metabolic syndrome and DM when the appendicular muscle index is used in diagnosing sarcopenic obesity, there are also studies demonstrating just the opposite [10,17]. Moreover, many studies determined an inconsistency between skeletal muscle index and appendicular muscle percentage [4,11,17-

19]. Since skeletal muscle index shows a high correlation with BMI, it is considered as a limited measure in defining sarcopenia in overweight and obese subjects. Appendicular muscle percentage is suggested to be a more appropriate method as it shows a negative correlation with BMI [4,11,12,15,17-19].

Total muscle percentage is another formula used in diagnosing sarcopenic obesity [2]. In the present study, it was observed that total muscle percentage decreased gradually from the overweight group to the class 3 obesity group and different from the appendicular muscle percentage, this decrease was observed also between the overweight and class 1 obesity groups. Recent studies determined significantly low total muscle percentage in the subjects the relationship with metabolic syndrome or hepatosteatosis [9,13,20]. A study evaluating between sarcopenic obesity and metabolic syndrome propounded that total muscle percentage is more useful than appendicular muscle index [16]. The present study concluded that total muscle percentage may be a more accurate method in diagnosing sarcopenia in the subjects with BMI>25 kg/m^2.

Another formula used in diagnosing sarcopenia is the total muscle index. In the present study, total muscle index showed a significant increase from the overweight group to the class 3 obesity group. An earlier study determined a significantly higher total muscle index in the subjects with metabolic syndrome [20]. As a consequence, the use of total muscle index in the diagnosis of sarcopenia may not be appropriate in obese diabetic person.

Different from the appendicular muscle index and appendicular muscle percentage, ASM/BMI ratio, which is an index developed in the recent years to diagnose sarcopenic obesity, decreases after the third decade of life and therefore it is considered as a potentially better indicator than skeletal muscle index [4,7]. In the present study, ASM/BMI ratio showed a significant decrease from class 1 to class 3 obesity group, but no difference was determined between the overweight and class 1 obesity groups. Accordingly, it is thought that ASM/BMI ratio is convenient in diagnosing sarcopenic obesity in the subjects with BMI $\geq$ 30 kg/m^2 but may remain incapable in overweight subjects.

The decrease in muscle mass, which is the target organ for insulin, may result in decreased insulin sensitivity and impaired glucose regulation [15]. In the present study, total muscle percentage and ASM/BMI ratio were found to be higher in the group with poor blood glucose regulation. Different from the present study, a study determined the negative correlation between total muscle percentage and HbA1c, which might have resulted from that study's being a population-based study [8].

One of the limitations of the present study is a low number of male patients and the other limitation is the use of BIA method in evaluating muscle mass. Although imaging methods are the best in assessing body muscle mass and fat mass, bone mineral density (DEXA) and BIA are the methods used most frequently in clinical practice [1]. BIA method is a good alternative to DEXA as it is cheap, portable, easy to use, and does not contain radiation [1]. Although an earlier study determined a good correlation between the BIA method and magnetic resonance imaging method, imaging methods are the gold standards in assessing muscle mass [1]. The other limitation of the present study is the fact that DM patients that formed the study universe were being followed in a diabetes center and accordingly had better blood glucose regulation as compared to the diabetic patients in the population.

CONCLUSION

In conclusion, sarcopenia, which has significant impacts on quality of life, functionality, morbidity, and mortality, is more prevalent particularly in type 2 diabetes mellitus patients than the normal population. Nevertheless, muscle mass shows high correlation with body weight and therefore making the diagnosis of sarcopenia in obese subjects becomes difficult. Moreover, there is no method agreed in diagnosing sarcopenia. The results of the present study suggest that total mass percentage may be more useful in evaluating muscle mass in overweight and obese subjects.

DECLARATIONS

Conflict of Interest

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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