INTRODUCTION

Sarcopenia is increasingly becoming a critical health problem because of increasing number of elderly people all over the world. Insulin resistance is one of the underlying mechanisms of sarcopenia, and the risk of sarcopenia was determined to be increased in type 2 diabetes mellitus (DM). Besides, sarcopenia can contribute to the development of insulin resistance and DM as skeletal muscle plays a significant role in plasma glucose consumption. The studies on the effects of DM on skeletal muscle mass are limited in number. As numerous formulas and methods have been used for assessing muscle mass, therefore, the prevalence of sarcopenia varies among studies. Even in old age, the prevalence of sarcopenia is very variable in the literature, although clinical studies related to sarcopenia is often conducted among older adult populations. In addition, there are limitations in assessing muscle mass due to the increased fat mass in obese subjects.

The present study aimed to assess the frequency of sarcopenia in type 2 diabetes mellitus patients using different formulas of bioimpedance analysis.

METHODOLOGY

The cross-sectional study included DM patients \( \geq 18 \) years with \( \text{BMI} \geq 30 \text{ kg/m}^2 \). BIA measurements consisted of body weight, height, total muscle mass and sum of the muscle masses of the four limbs (ALM). Skeletal muscle index, total muscle index, skeletal muscle percentage, total muscle percentage, and ALM/BMI were used for muscle-related analyses. The data were presented as frequency, mean ± standard deviation, and percentage. Student t-test was used to compare differences between two independent groups.

Results: A total of 295 DM patients were enrolled in the study, of whom 176 (59.66%) were females, 119 (40.34%) were males, 47 (15.93%) were over the age of 65 years, and the mean age was 53.39 ± 10.39 years. Sarcopenia was determined in 40 males (33.61%) by body muscle ratio, in 15 males (12.60%) by ALM/BMI ratio, and in one male participant (0.84%) by skeletal muscle index. Among female participants, while sarcopenia was determined in 61 (34.65%) by body muscle ratio and in 1 (0.56%) by ALM/BMI ratio, no sarcopenia case was detected using skeletal muscle index.

Conclusion: The frequency of sarcopenia in obese diabetic patients is found to be lower when skeletal muscle index and ALM/BMI ratio is used, but higher with body muscle ratio.

Key Words: Diabetes mellitus type 2. Sarcopenia. Obesity. Muscle weakness.
HbA1c concentration was measured on the same day of BIA measurements by chromatographic method in bio-radiowariant II analyser (Bio-Rad, Richmond, CA, USA). BIA measurements consisted of body weight, height, total muscle mass, and sum of the appendicular muscle masses (ALM) of the four limbs. Body mass index (BMI) was calculated as the body weight in kilograms divided by square meter of the height (kg/m²). In addition, body fat percentage was calculated as the ratio of total fat mass to body weight multiplied by 100. In order to calculate body muscle mass by BIA, the formula 
\[ \text{Body muscle mass} = \left( \frac{\text{height}^2 \, \text{cm}}{\text{BIA resistance} \times 0.401} + (\text{gender} \times 3.825) + (\text{age} \times -0.071) \right) + 5.102 \]
was used, and then the skeletal muscle index was assessed as the body muscle mass divided by the square meter of height, and body muscle ratio was assessed as the body muscle mass divided by the body weight. For the skeletal muscle index and body muscle ratio, a standard deviation of -2 and lower than the mean values predetermined for young adult population is considered as class 2 sarcopenia, a standard deviation from -1 to -2 is considered as class 1 sarcopenia, and a standard deviation of -1 and higher is considered normal. According to ALM/BMI ratio, sarcopenia is divided into two groups as normal and sarcopenic. The cut-off values for the measurements used to assess muscle mass are summarised in Table I.

The data were analysed using SPSS 22.0 programme and presented as frequency, percentage, mean ± standard deviation. Student t-test was performed for continuous variables with normal distribution and Mann-Whitney U-test was used for continuous variables with abnormal distribution. P-value <0.05 was considered statistically significant. Kolmogorov-Smirnov test and Shapiro-Wilk test were used to evaluate data distribution and to test data for normality.

**RESULTS**

A total of 295 patients were enrolled in the study. Of the participants, 176 (59.66%) were females, 119 (40.34%) were males, and 47 (15.93%) were over the age of 65 years. The mean age of the participants was 53.39 ±10.39 (20.00-80.00) years and the mean HbA1c was 7.22 ±1.65%. Dividing the participants into BMI groups according to the obesity status; 64 (21.7%) were in the BMI = 30.00-34.99 kg/m² group, 90 (30.5%) were in the BMI = 35.00-39.99 kg/m² group, and 141 (47.8%) were in the BMI >40.00 kg/m² group. BIA measurements of the participants, according to the gender, are summarised in Table II.

When the frequency of sarcopenia among the male participants was determined using body mass ratio, it was found that 31 (26.05%) had class 1 sarcopenia, and 9 (7.56%) had class 2 sarcopenia. ALM/BMI ratio indicated sarcopenia was found in 15 (12.60%) male participants, whereas skeletal muscle index indicated class 1 sarcopenia was found in 1 (0.84%) participant. In female participants, body mass ratio indicated class 1 sarcopenia in 56 (31.81%), and class 2 sarcopenia in 5 (2.84%) participants; ALM/BMI ratio indicated sarcopenia in 1 (0.56%) participant, whereas no sarcopenia was detected in female participants using skeletal muscle index. Frequency of sarcopenia according to the genders determined by body muscle ratio and ALM/BMI ratio is demonstrated in Figure 1.

**DISCUSSION**

Impacts of sarcopenia are estimated to become more important in the next decade due to increasing population of elderly people. The prevalence of DM,
which is a significant risk factor for sarcopenia, is expected to exceed 30% until the year 2050 in people at and over the age of 75 years. There is no consensus on the method to be used for the diagnosis of sarcopenia, and different cut-off values are used for each method and formula. Therefore, prevalence of sarcopenia varies depending on the differences among the methods of measurement, reference populations and cut-off values.

The present study aimed to assess the frequency of sarcopenia in DM patients using different formulas of BIA.

Prevalence of sarcopenia shows large differences in the literature depending on the methods and formulas used for the diagnosis of sarcopenia even among elderly people. In a study evaluating the prevalence of sarcopenia using body muscle ratio, class 1 and class 2 sarcopenia was determined in 44.0% and 7.5% of male participants, respectively; while corresponding figures were 60.3% and 12.2% in female participants. In a study conducted in DM patients using dual-energy X-ray absorptiometry (DEXA), the prevalence of sarcopenia was 15.7% according to body muscle ratio; whereas the prevalence of sarcopenia was 6.2-12.5% in males and 5.9-23.6% in females in the studies performed with BIA.

While there are many methods used for the evaluation of muscle mass, the most commonly used methods are DEXA scan and BIA. BIA is a frequently preferred and good alternative method as it is cheap, practical and non-invasive as compared to the other methods. In the studies evaluating the prevalence of sarcopenia in elderly using skeletal muscle index, the prevalence ranged from 3.6% to 68.0% in males and from 2.8% to 21.0% in females. The studies performed using DEXA scan, a different method of measurement, reported the prevalence of sarcopenia to be 11.3-23.4% in males and 1.5-36.7% in females, using skeletal muscle index. In the present study evaluating the frequency of sarcopenia, body muscle ratio usage revealed class 1 sarcopenia in 25.0% and class 2 sarcopenia in 7.25% of male participants, whereas class 1 sarcopenia was determined in 31.81% and class 2 sarcopenia was determined in 2.84% of female participants. However, the frequency of sarcopenia was found to be 0.80% in male participants and in none of the female participants, when skeletal muscle index was used. In addition, ALM/BMI ratio, a recently developed index for the diagnosis of sarcopenia, was used to determine the prevalence of sarcopenia in the present study; and the frequency of sarcopenia was found to be 12.09% in males and 0.56% in females.

To the authors’ knowledge, there is no study in the literature evaluating the frequency of sarcopenia in DM patients using ALM/BMI ratio. Nevertheless, in the studies evaluating the appendicular muscle mass according to body height and weight with DEXA scan method, the prevalence of sarcopenia ranged from 20.0 to 33.3% in males and from 20.3 to 25.6% in females. Moreover, again a study evaluating the appendicular muscle mass according to height and body fat mass reported class 1 sarcopenia in 29.5% and class 2 sarcopenia in 9.7% of males, and class 1 sarcopenia in 30.3% and class 2 sarcopenia in 11.8% of females. In a population-based study conducted in elderly using DEXA scan method, the prevalence of sarcopenic obesity, which was evaluated as the sum of the muscle masses of the extremities divided by the height, was found to be 16.7% in males and 5.7% in females; however, the prevalence increased to 35.1% in males and 48.1% in females when it was evaluated as the sum of the muscle masses of the extremities divided by the body weight.

In the present study, the frequency of sarcopenia was found to be lower than the other studies with all formulas used. The reason for this might be that, different from the other studies, majority of the study participants were middle-aged and the ratio of elderly participants was very low. Although sarcopenia is considered to be an important problem for the health of elderly people, studies on this topic have usually been conducted in elderly people but, the decrease in muscle mass began after third decade. Another reason is that, the diagnosis of sarcopenia could be masked due to excessive fat mass in obese subjects. Since there is a correlation between muscle mass and body mass index (BMI), assessment of muscle mass becomes more difficult in obese subjects, such as diabetes mellitus.

In a study, the prevalence of sarcopenia assessed as the sum of the muscle masses of the extremities divided by the height was determined to be 8.9% in overweight males and 0.8% in overweight females, while no sarcopenia case was determined in the obese subjects of each gender. Nevertheless, when the fat-free body mass was re-adjusted according to height and body weight, the prevalence of sarcopenia was determined to be higher in both overweight and obese subjects.

As the studies in the literature are usually population-based studies, they comprise patients from all BMI groups. However, the present study included only the obese DM patients, of whom 47% were morbid obese. As a result, the presence and the degree of sarcopenia might have been masked due to the obesity status of the participants.

One of the most significant limitations of the present study is the undocumented duration of DM. Since insulin resistance has a significant impact on the development of sarcopenia, it can be considered during the time span the patients have been exposed to this effect might influence the frequency and degree of sarcopenia.
Another limitation of the present study is the lack of the assessment of the muscle strength of the participants.

CONCLUSION
The frequency of sarcopenia is lower in obese diabetic patients, if skeletal muscle index and ALM/BMI ratio are used; but higher, if body muscle ratio is used. In the light of these results, developing new diagnostic formulas may be necessary, particularly in obese and middle-aged population with risk factors like DM.

REFERENCES

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