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# Association between Fat Mass, Total Energy Metabolism, and Sarcopenia in Older Zhuang Adults from Southwest China: A Cross-Sectional Study

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## Abstract

**Objective**: The present study aimed to investigate the prevalence of sarcopenia and associated risk factors among older Zhuang adults residing in Southwest China. **Methods:** A total of 1757 participants aged 60 years, comprising 1015 females and 742 males were recruited. The height and weight were determined using a height meter and scale, respectively. The skeletal muscle mass index was estimated using a bioelectrical impedance analysis-based body composition analysis to quantify the muscle mass of the upper and lower limbs, fat mass, total energy metabolism, and basal metabolism. **Results:** The total prevalence of sarcopenia was 29.37%, including 12.92% male and 16.45% female, The prevalence rates of male and female were 30.59% and 28.47%, respectively. The sarcopenia group was older and had lower BMI, fat mass, basal metabolism, and total energy metabolism ($p < 0.001$) than the non-sarcopenia group. Age, gender ($\beta = 0.585$, $p < 0.001$), BMI ($\beta = 0.313$, $p < 0.001$), fat mass ($\beta = 0.116$, $p < 0.001$), and total energy metabolism ($\beta = 0.001$, $p < 0.001$) were shown to be predictors of skeletal muscle mass index by linear regression analysis. Age, male gender (*OR* = 11.860, 95% *CI*: 5.691 - 24.717, $p < 0.001$), and fat mass (*OR* = 1.952, 95% *CI*: 1.769 - 2.154, $p < 0.001$) were identified as risk variables for sarcopenia in the older adult of Guangxi Zhuang. BMI (*OR* =

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0.193, 95% *CI*: 0.157 - 0.237, p < 0.001) and total energy metabolism (*OR* = 0.993, 95% *CI*: 0.992 – 0.994, p < 0.001) were protective variables against sarcopenia. Age, male gender, and fat mass remained risk variables for sarcopenia after stratified analysis based on BMI. **Conclusion:** The frequency of male sarcopenia in the senior population of Zhuang is greater than that of females. Low BMI, fat mass, basal metabolism, and total energy metabolism were seen in individuals with sarcopenia. Age and fat mass are risk factors for sarcopenia. Total energy metabolism is a sarcopenia preventive factor.

## Keywords

Sarcopenia, BMI, Fat Mass, Basal Metabolism, Total Energy Metabolism, Skeletal Muscle

## 1. Introduction

Sarcopenia (SP) is characterized by an age-related loss of skeletal muscle strength and athletic ability. It is the leading cause of physical weakness, dysfunction, poor health-related quality of life, and the risk of early mortality in the aged [1]. As the Chinese population ages, the incidence of sarcopenia will surely increase.

In 2000, projected direct medical expenditures for sarcopenia in the United States were $18.5 billion [2]. At the same time, in Europe, the cost of hospitalization for older patients with sarcopenia was five times that of senior patients without sarcopenia [3]. A large community study in the Czech Republic discovered that the direct healthcare expenses for older individuals with sarcopenia were more than twice as high as those without sarcopenia [4].

The prevalence of sarcopenia varies according to study samples, definitions, and assessment methodologies [5]. Many studies have shown that age [6], BMI [7], fat mass [8] and basal and total energy metabolism [9] are the primary determinants of sarcopenia. Therefore, this study assumes that age, BMI, fat mass, basic metabolism, and total energy metabolism are the primary influencing factors of sarcopenia in Zhuang older adult individuals in Southwest China and investigates the correlation between these factors and sarcopenia in Zhuang older adult individuals in Southwest China.

The makeup of the human body will alter dramatically with age, which is most apparent in the senior population, and there are regional and ethnic variations. Studies imply that racial differences in muscle mass [10] are influenced by genetics [11], hormones [12], and lifestyles [13].

The Zhuang population is the most populous ethnic minority in China, with a population of 19.568 million, mainly living in the Guangxi Zhuang Autonomous Region. They have a long history and splendid culture, but they also face some health differences, such as a higher incidence of osteoporosis and a lower life expectancy than other ethnic groups in China. At present, the incidence and influencing factors of sarcopenia in the Zhuang population are not clear, and it is not clear whether there are differences with other ethnic groups. Therefore, this study will investigate the prevalence and risk factors of sarcopenia in the elderly Zhuang population in China, and provide evidence-based interventions to improve their muscle health and quality of life, which will help to narrow these differences.

## 2. Data and Methods

### 2.1. General Data

In this study, a cross-sectional survey of the Zhuang elderly in southwest China was conducted by cluster sampling method. From January 2020 to January 2022, 1757 elderly Zhuang over 60 years old were selected from six different towns in southwest China as the research object. We selected six different townships in three regions of southwest China for the survey. All participants were familiarized with the research process before entering the group, and were interviewed and evaluated by experienced interviewers after obtaining written consent. The inclusion criteria of the population involved in the survey are: (1) Zhuang people within three generations, (2) age not less than 60 years old, (3) no bedridden dependence, no serious physical disease, and good self-care ability in daily life; exclusion criteria: (1) Zhuang people with serious physical and mental diseases, (2) Non-zhuang people within three generations. A total of 1757 people met the inclusion criteria of this study.

### 2.2. Height and Weight Measurement

The patients were measured for height (in centimeters) and weight (in kilograms) using a height meter and a scale, respectively. The measurements were exact to the last decimal place. The formula for calculating body mass index (BMI) is weight in kilograms divided by square meters of height (kg/m$^2$).

### 2.3. Body Composition Measurements

Using the bioelectrical impedance technique and a Tanita MC-180 Body Composition Analyzer, the body's upper and lower limb muscle mass and fat mass, total energy metabolism, and basal metabolism were assessed. Appendicular skeletal muscle mass is the total of the limbs' skeletal muscle mass in kilograms (kg).

### 2.4. Diagnosis of Sarcopenia

The present investigation diagnosed sarcopenia using the Asian Working Group for Sarcopenia criteria [1]. The formula is limb skeletal muscle mass divided by the square of height. Males with an SMI < 7.0 kg/m$^2$ and females with an SMI < 5.7 kg/m$^2$ were diagnosed with sarcopenia, and the individuals were separated into sarcopenia (n = 516) and non-sarcopenia (n = 1241) groups.

### 2.5. BMI Group

According to Chinese standards, BMI groups were divided into the underweight group (BMI < 18.5 kg/m$^2$), normal weight group (18.5 kg/m$^2$ ≤ BMI < 24.0 kg/m$^2$), overweight group (24.0 ≤ BMI < 28.0 kg/m$^2$), and obesity group (≥28.0 kg/m$^2$) [14].

### 2.6. Statistical Analysis

SPSS 26.0 statistical software was used to analyze the data. The Kolmogorov-Smirnov test was used to determine whether or not the indicators of participants follow a normal distribution. The mean standard deviation is used to represent measurement data with a normal distribution. The Mann-Whitney U test was used to test for differences between two independent samples when the data were normally distributed and the chi-squared could not meet the requirements of the t-test. The measurement data were provided as mean standard deviation (mean ± SD), and the Categorical data as percentages. An independent, two-tailed t-test was used to compare the differences between two sets of circumstances. Chi-square tests were used to compare categorical data. Multivariate linear regression was used to predict the independent risk factors of SMI, and multivariate logistic regression analysis was used to evaluate the risk variables of sarcopenia.

## 3. Results

### 3.1. Baseline Demographic Data of the Study Population

There were 1757 eligible patients, including 1015 females and 742 males. The average male age was (68.91 ± 6.66) years, the average female age was (69.46 ± 7.22) years, and the overall average age was (69.23 ± 6.99) years. Females' average age and body mass index were not significantly different from males, whereas muscle mass, basal metabolic rate, and total energy metabolism rate were lower ($p < 0.001$), and fat mass was greater ($p < 0.001$) (see **Table 1**). A total of 516 (29.37%, 516/1757) sarcopenia patients were studied, comprising 227 (43.99%, 227/516) men and 289 (56.01%, 289/516) females. Male and female sarcopenia prevalence rates were 30.59% (227/742) and 28.47% (289/1015), respectively (**Table 1**, **Figure 1**).

**Table 1.** The baseline demographic data of the study population.

| Index | Male | Female | Total |
|---|---|---|---|
| n | 742 | 1015 | 1757 |
| Age(year) | 68.91 ± 6.66 | 69.46 ± 7.22 | 69.23 ± 6.99 |
| BMI | 22.67 ± 3.21 | 22.67 ± 3.28 | 22.67 ± 3.25 |
| Muscle mass (kg) | 43.85 ± 5.79 | 32.83 ± 3.75* | 37.48 ± 7.21 |
| Fat mass (kg) | 11.39 ± 5.52 | 15.06 ± 5.9* | 13.51 ± 6.02 |
| Basal metabolism (KJ) | 1239.19 ± 178.04 | 994.64 ± 126.32* | 1097.92 ± 192.84 |
| Total energy metabolism (KJ) | 1840.19 ± 264.38 | 1477.04 ± 187.57* | 1630.40 ± 286.36 |

*Female vs. male, $p < 0.001$.

The detection rates of sarcopenia in the underweight, normal weight, overweight, and obese categories were 7.97%, 20.55%, 0.85%, and 0%, respectively. The detection rate of sarcopenia in the normal weight group was the highest among them (**Figure 2**). The number of participants in each BMI category is shown in **Figure 3**.

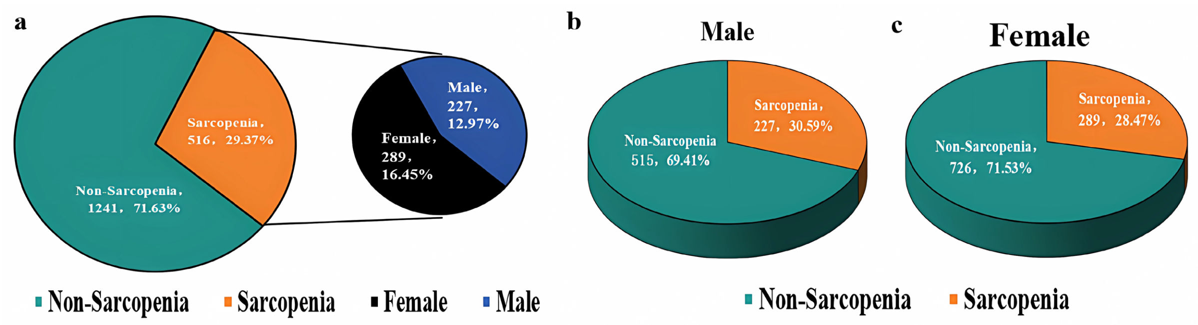


**Figure 1.** (a) Male and female sarcopenia prevalence rates; (b) Prevalence of sarcopenia in elderly male Zhuang nationality; (c) Prevalence of sarcopenia in elderly female Zhuang nationality.

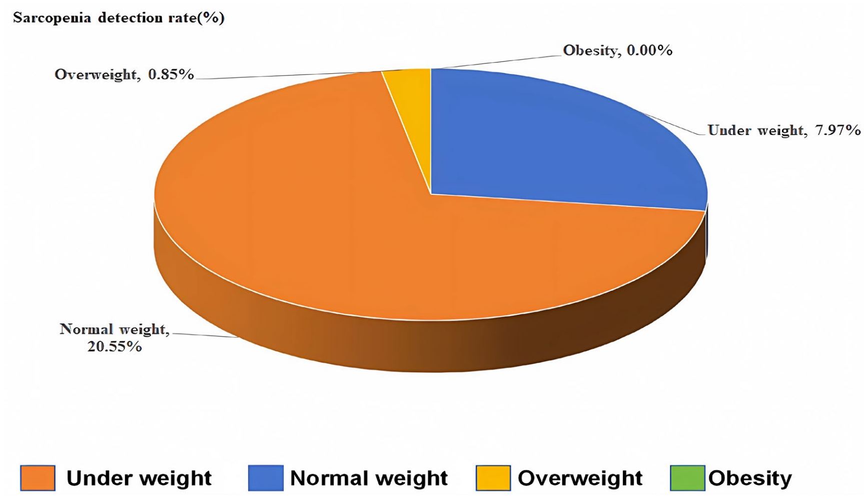


**Figure 2.** The detection rate of sarcopenia in the normal weight group was the highest among them.

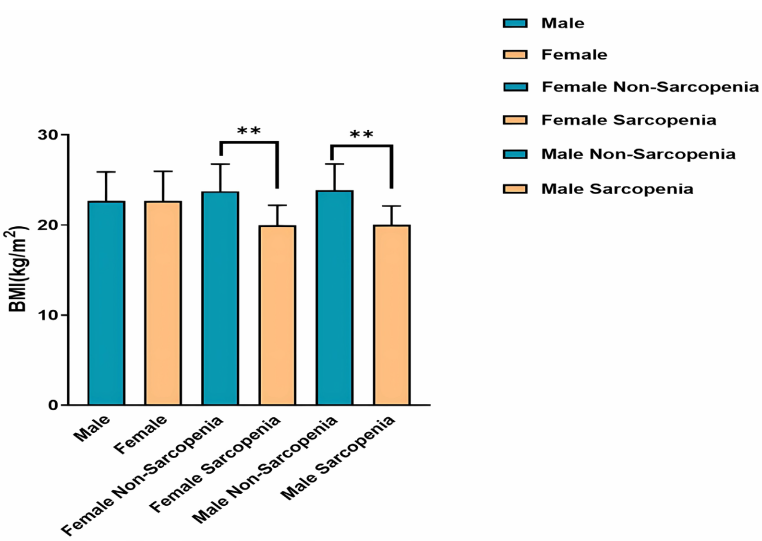


**Figure 3.** The number of participants in each BMI category.

### 3.2. Comparison of Indexes between the Sarcopenia Group and Non-Sarcopenia Group

When comparing the sarcopenia group to the non-sarcopenia group, the sarcopenia group's age was higher ($p < 0.001$), and their BMI, muscle mass, fat mass, SMI, basal metabolism, and total energy metabolism were lower ($p < 0.01$, Table 2, Figure 4(a)).

Table 2. Comparison of indicators between the sarcopenia group and non-sarcopenia group.

| Indicators | Non-sarcopenia group | Sarcopenia group | p-Value |
|---|---|---|---|
| N (%) | 1241 (70.60%) | 516 (29.40%) | — |
| Age (years) | 67.71 ± 6.12 | 72.88 ± 7.60 | <0.001 |
| BMI (kg/m²) | 23.79 ± 2.96 | 19.98 ± 2.17 | <0.001 |
| Muscle mass (kg) | 38.96 ± 7.28 | 33.92 ± 5.60 | <0.001 |
| Fat mass (kg) | 14.86 ± 6.15 | 10.25 ± 4.17 | <0.001 |
| SMI (kg/m²) | 7.09 ± 1.09 | 5.83 ± 0.69 | <0.001 |
| Basal metabolism (KJ) | 1147.35 ± 189.42 | 979.04 ± 142.70 | <0.001 |
| Total energy metabolism (KJ) | 1703.80 ± 281.27 | 1453.87 ± 211.93 | <0.001 |

Note: Comparison between sarcopenia and non-sarcopenia, the total number of two groups n = 1757, including 516 sarcopenias and 1241 non-sarcopenia.

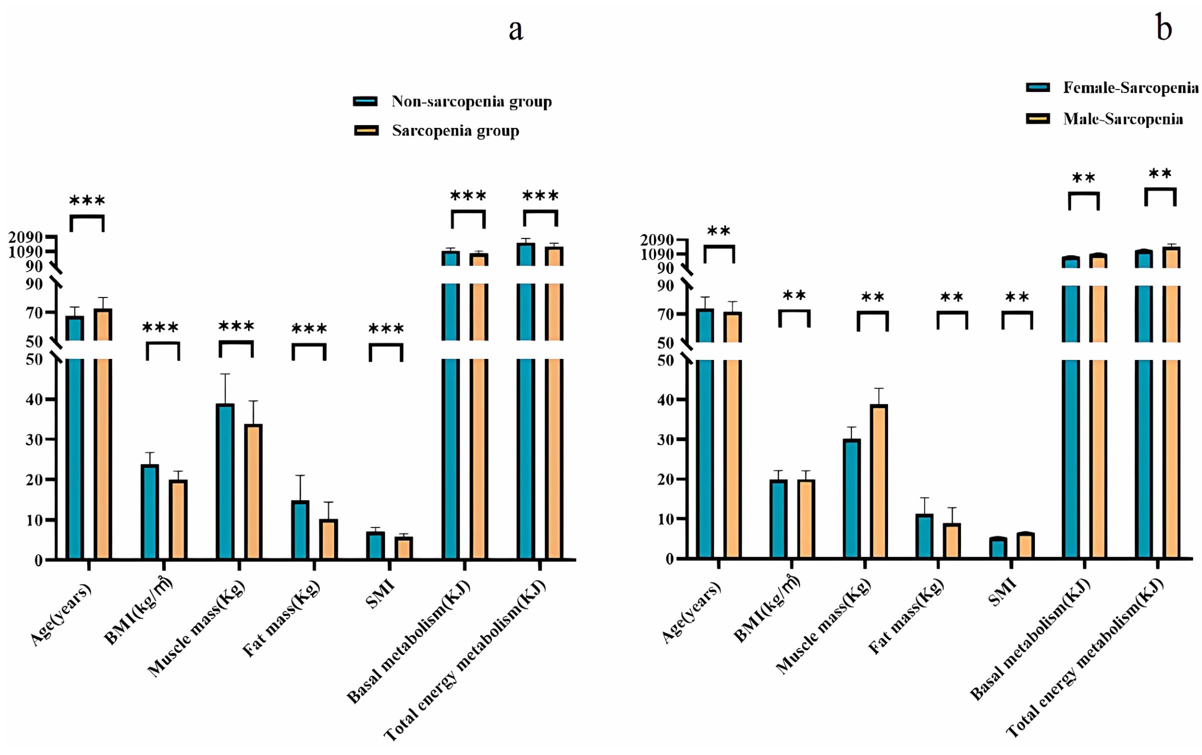


Figure 4. (a) Comparison of indexes between the sarcopenia group and non-sarcopenia group, (b) Indicators between sarcopenia groups of different genders. *p < 0.05. **p < 0.01. ***p < 0.001. SMI: Skeletal muscle index.

### 3.3. Comparison of Each Index between Sarcopenia Groups of Different Gender and Corresponding Non-Sarcopenia Group

Age, BMI, muscle mass, fat mass, SMI, basal metabolism, and total energy metabolism were statistically significant ($p < 0.01$) when compared to the same gender group (see Table 3). The average age of the sarcopenia group was greater than the non-sarcopenia group. BMI, muscle mass, fat mass, SMI, basal metabolism, and total energy metabolism were lower in the sarcopenia group than in the non-sarcopenia group (Figure 4(a)).

**Table 3.** Comparison of indicators between sarcopenia groups of different genders and corresponding non-sarcopenia groups.

| Indicators | Female Non-Sarcopenia | Female Sarcopenia | Male Non-Sarcopenia | Male Sarcopenia |
|---|---|---|---|---|
| N (%) | 726 (41.32) | 289 (16.45) | 515 (29.31) | 227 (12.92) |
| Age (years) | 67.67 ± 6.13 | 73.97 ± 7.79$^{b}$ | 67.77 ± 6.10 | 71.51 ± 7.13$^{b, d}$ |
| BMI (kg/m$^2$) | 23.75 ± 2.99 | 19.96 ± 2.22$^{b}$ | 23.85 ± 2.91 | 20.02 ± 2.10$^{b}$ |
| Muscle mass (Kg) | 33.91 ± 3.42 | 30.10 ± 3.10$^{b}$ | 46.08 ± 4.97$^{d}$ | 38.80 ± 4.08$^{b, d}$ |
| Fat mass (Kg) | 16.55 ± 5.86 | 11.31 ± 4.04$^{b}$ | 12.48 ± 5.75$^{d}$ | 8.92 ± 3.95$^{b, d}$ |
| Skeletal muscle index (SMI = AMS/h$^2$) | 6.41 ± 0.53 | 5.33 ± 0.33$^{b}$ | 8.04 ± 0.96$^{d}$ | 6.47 ± 0.47$^{b, d}$ |
| Basal metabolism (KJ) | 1034.33 ± 114.21 | 894.96 ± 96.96$^{b}$ | 1306.67 ± 157.10$^{d}$ | 1086.08 ± 117.80$^{b, d}$ |
| Total energy metabolism (KJ) | 1535.97 ± 169.59 | 1329.00 ± 143.96$^{b}$ | 1940.39 ± 233.28$^{d}$ | 1612.85 ± 174.96$^{b,d}$ |

Note: Comparison between the same gender group, $^{a}p < 0.05$, $^{b}p < 0.01$; Comparison between the same BMI group of different genders $^{c}p < 0.05$, $^{d}p < 0.01$.

The muscle mass, fat mass, SMI, basal metabolism, and total energy metabolism in the female non-sarcopenia group and the male non-sarcopenia group were statistically significant ($p < 0.01$) when compared to the same group of different genders (see Table 3).

The female sarcopenia group outperformed the male sarcopenia group in age, muscle mass, fat mass, SMI, basal metabolism, and total energy metabolism ($p < 0.01$). (Figure 4(b)) The male group had a lower average age and fat mass than the female group.

### 3.4. Gender Detection Rate of Sarcopenia in Different Weight Grades

At various weight levels (according to BMI), the percentage of male groups with or without sarcopenia was as follows. Sarcopenia: 90.00% underweight, 36.05% normal weight, 2.78% overweight, and 0.00% obese. The intra-group percentage of patients with sarcopenia decreases as BMI rises (Figure 5).

The following are the proportions of female groups with or without sarcopenia at various weight levels (according to BMI). Sarcopenia: 79.38% are underweight, 34.12% are normal weight, 3.82% are overweight, and 0.00% are obese. The intra-group percentage of patients with sarcopenia decreases as BMI rises (Figure 6).

The detection rate of sarcopenia in men was greater than that in females in the underweight and normal weight groups but lower than in females in the overweight group (Figure 7).

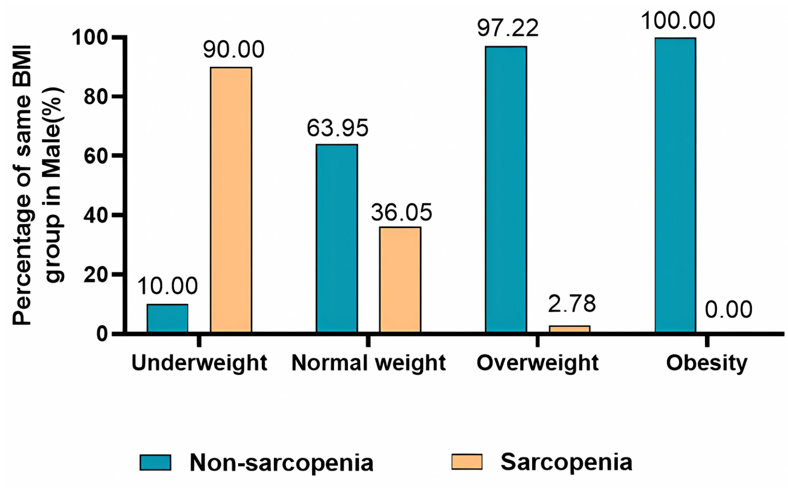


**Figure 5.** The intra-group percentage of patients with sarcopenia decreases as BMI rises.

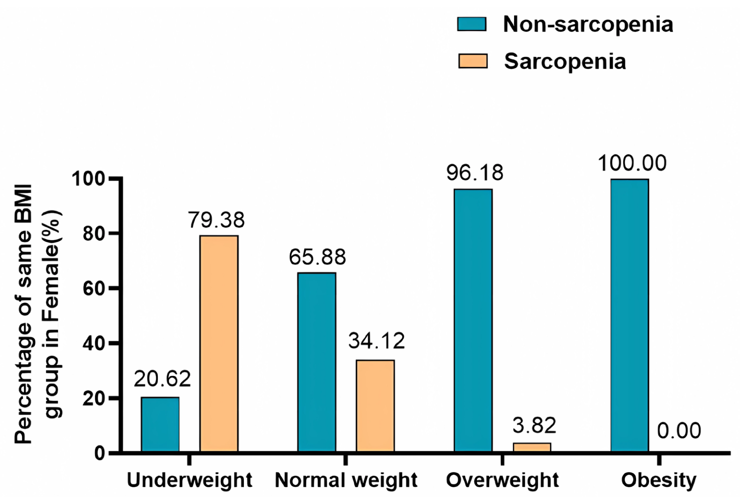


**Figure 6.** The intra-group percentage of patients with sarcopenia decreases as BMI rises.

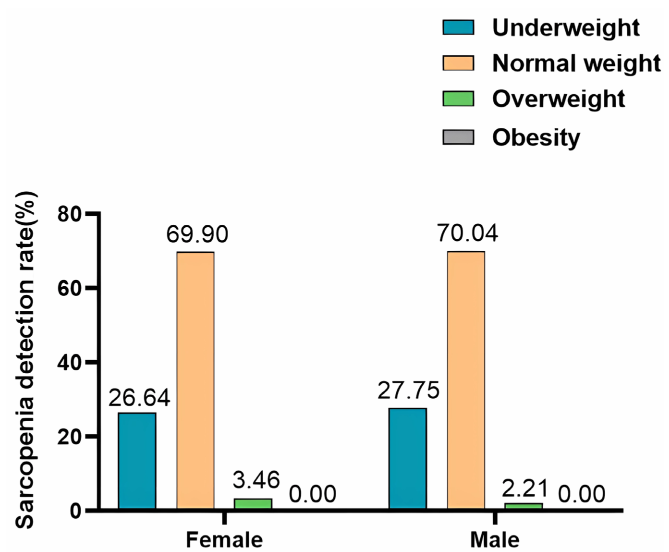


**Figure 7.** The detection rate of sarcopenia in men was greater than that in females.

### 3.5. Proportion of Sarcopenia and Non-Sarcopenia in the Same Weight Group

The proportion of sarcopenia in the group with or without sarcopenia in the same weight level (according to BMI) group was as follows: the underweight group was 83.83%, the normal weight group was 34.95%, the overweight group was 3.39%, the obesity group was 0.00% (Figure 8).

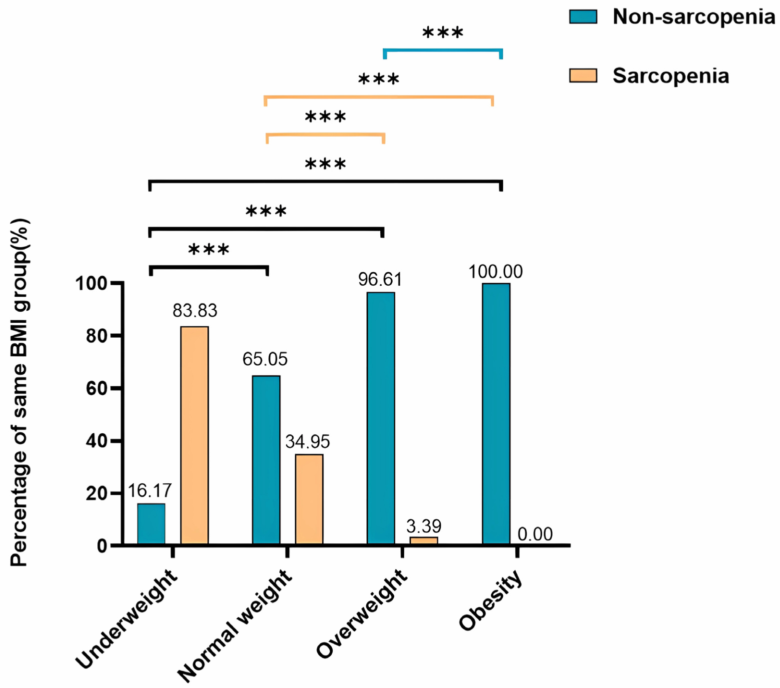


Figure 8. The proportion of sarcopenia in the group with or without sarcopenia in the same weight level (According to BMI) group.

### 3.6. Analysis of Independent Predictive Factors of SMI

When age, BMI, and fat mass were all considered simultaneously, (1) age ($P < 0.001$) and fat mass ($p < 0.001$) were inversely connected with SMI, whereas BMI was positively correlated with SMI ($p < 0.001$).

When age, gender, BMI, and fat mass are all considered, the result is the same as (1). SMI in men is greater than in women ($p < 0.001$).

When age, BMI, fat mass, and total energy metabolism are all included, the result is the same as (1), and the total energy metabolism component is positively associated ($p < 0.001$).

When the effects of age, gender, BMI, fat mass, and total energy metabolism on SMI are considered together, the outcomes are the same as (1). Males have a greater SMI than females ($P < 0.001$), and the effect factor of total energy metabolism is positively connected ($P < 0.001$). Because the basic metabolism and total energy metabolism are collinear (higher than 10), the influencing factor is not included in the calculation.

According to BMI for weight stratification study, the outcome is consistent with non-stratification, as shown in supplemental Table 4.

Table 4. SMI independent prediction factor analysis.

| Variable | Model 1 | | Model 2 | | Model 3 | | Model 4 | |
|---|---|---|---|---|---|---|---|---|
| | $R^2 = 0.672$ | | $R^2 = 0.793$ | | $R^2 = 0.796$ | | $R^2 = 0.819$ | |
| | $\beta$ | partial correlation coefficient | $\beta$ | partial correlation coefficient | $\beta$ | partial correlation coefficient | $\beta$ | partial correlation coefficient |
| Age (years) | −0.029* | −0.294 | −0.030* | −0.367 | −0.014* | −0.184 | −0.021* | −0.265 |
| Gender[a] | - | - | 0.997* | 0.607 | - | - | 0.585* | 0.336 |
| BMI (kg/m²) | 0.522* | 0.796 | 0.372* | 0.707 | 0.324* | 0.626 | 0.313* | 0.634 |
| Fat mass (kg) | −0.214* | −0.709 | −0.120* | −0.497 | −0.144* | −0.603 | −0.116* | −0.509 |
| Basal metabolism (KJ) | - | - | - | - | - | - | - | - |
| Total energy Metabolism (KJ) | - | - | - | - | 0.002* | 0.614 | 0.001* | 0.352 |

Note: This variable is not included, /this variable has been included, but the equation is automatically excluded, a: female = 0, male = 1. *p < 0.001.

### 3.7. Analysis of Risk Factors for Sarcopenia

When the effects of age, BMI, and fat mass on sarcopenia were considered, (2) age (P < 0.001) and fat mass (P < 0.001) were risk factors, while BMI was a protective factor (P<0.001), age *OR* = 1.140 (95% *CI*: 1.116 - 1.165), fat mass *OR* = 1.341 (95% *CI*: 1.264 - 1.423), and BMI *OR* = 0.311 (95% *C*I:0.271-0357) (Table 5, Model 1).

When age, BMI, and fat mass are all considered, the result remains the same as (2). Males are more likely than females to develop sarcopenia (P < 0.001). The OR for age is 1.155, gender is 8.690, BMI is 0.188, and fat mass is 1.752 (Table 5, model 2).

When age, BMI, fat mass, basal metabolism, and total energy metabolism are considered in relation to sarcopenia, the result is the same as (2), and the basal metabolism and total energy metabolism are not statistically significant. *OR* = 1.140 for age, *OR* = 0.311 for BMI, and *OR* = 1.341 for fat mass (Table 5, model 3).

When the effects of age, gender, BMI, fat mass, basic metabolism, and total energy metabolism on sarcopenia are considered concurrently, the conclusion is the same as that of (2). Males are more likely than females to develop sarcopenia (P < 0.001), and total energy metabolism is a protective factor for sarcopenia (P < 0.001). The OR for age is 1.115, gender is 11.860, BMI is 0.193, fat is 1.952, and total energy metabolism is 0.993. Because basic metabolism and total energy metabolism are collinear, the equation automatically contains just total energy metabolism variables (Table 5, Model 4).

According to BMI for weight stratification study, the outcome is consistent with non-stratification, as shown in supplemental Tables 1-4.

**Table 5.** Analysis of risk factors for sarcopenia.

| Ariable | Model 1 | Model 2 | Model 3 | Model 4 |
|---|---|---|---|---|
| | *OR* (95% *CI*) | *OR* (95% *CI*) | *OR* (95% *CI*) | *OR* (95% *CI*) |
| Age (years) | 1.140 (1.116 - 1.165)* | 1.155 (1.128 - 1.182)* | 1.140 (1.116 - 1.165)* | 1.115 (1.086 - 1.144)* |
| Gender[a] | - | 8.690 (5.696 - 13.258)* | - | 11.860 (5.691 - 4.717)* |
| BMI ($kg/m^2$) | 0.311 (0.271 - 0.357)* | 0.188 (0.156 - 0.228)* | 0.311 (0.271 - 0.357)* | 0.193 (0.157 - 0.237)* |
| Fat mass (kg) | 1.341 (1.264 - 1.423)* | 1.752(1.608 - 1.908)* | 1.341 (1.264 - 1.423)* | 1.952 (1.769 - 2.154)* |
| Basal metabolism (KJ) | - | - | / | / |
| Total energy metabolism (KJ) | - | - | / | 0.993 (0.992 - 0.994)* |

Note: This variable is not included, / this variable has been included, but the equation is automatically excluded, a: female = 0, male = 1. *$p < 0.001$.

## 4. Discussion

The aim of this study was to compare the body composition and sarcopenia status of elderly Zhuang people in southwest China, and to reveal the significant differences among elderly Zhuang people and their implications for healthcare planning and policy making. This study is the first to use standardized and validated methods to estimate the prevalence and risk factors for sarcopenia in elderly Zhuang people in China. It is also the first study to investigate the relationship between BMI, fat mass, total energy metabolism and sarcopenia in elderly Chinese Zhuang people, suggesting that some modifiable factors may prevent or delay sarcopenia. The main findings of this study are as follows: (1) The prevalence of sarcopenia among Zhuang people in southwest China was 29.37%, with 30.59% in males and 28.44% in females; (2) Sarcopenia patients are older and have lower BMI, muscle mass, fat mass, basal metabolism and total energy metabolism.

The incidence of sarcopenia has been studied previously shown that sarcopenia affects 1% to 29% of people of various ages and locales [15], including 14% to 33% of those who require long-term care [16]. In hospitals, 29.7% of older males and 23.0% of older females had sarcopenia. At sanatoriums, 26.3% of elderly males and 33.7% of older females had sarcopenia [17]. This study's findings match the previous one, despite regional health and sanatorium admittance norms. However, a study in Türkiye found that the frequency of sarcopenia was 5.2% [18]. In Asian Japan, the prevalence of sarcopenia in men and women was 11.5% and 16.7%, respectively [19]. This is quite different from the results of our study, which may be caused by different races [10], genes [11], hormones [12] and lifestyles [13].

Sarcopenia patients had a higher age, The experimental data suggests the following: In older adults, age is an independent negative predictor of skeletal muscle mass index ($\beta = -0.021$, $R^2 = 0.819$, $p < 0.001$). Muscles and $\alpha$-motor neurons change with age. Decreased growth hormone and sex steroid hormone production accelerates muscle ageing [20]. This correlation between age and the likelihood of having a low skeletal muscle mass index was strong [6] [21]. This was consistent with the findings of this study. Age is also a risk factor for sarcopenia in this study (*OR* = 1.115, 95% *CI*: 1.086 - 1.144, $p < 0.001$). The sarcopenia group's mean age was older than the non-sarcopenia group's ($p < 0.001$) [22]. This is consistent with previous findings.

According to this research, male skeletal muscle mass index is significantly high. This is in line with past research [22]-[24]. This research also discovered that men were at a greater risk of sarcopenia (*OR* = 11.860, 95% *CI*: 5.691 - 24.717, $p < 0.001$). This corresponds to earlier reports [24] [25]. Gender may be used as an independent predictor ($\beta = 0.585$, $p < 0.001$) of skeletal muscle mass index in older adult. In terms of gender, the male sarcopenia group outperformed the female sarcopenia group in age, muscle mass, fat mass, basal metabolism, and total energy metabolism ($p < 0.001$). Male sarcopenia patients have a younger age than female sarcopenia patients. When BMI is less than 24 kg/m$^2$, males have a higher detection rate of sarcopenia than females, but in the overweight group, females have a higher detection rate, which may be attributed to the small sarcopenia group. One research discovered that males had greater myostatin mRNA levels than females [26], and male muscle mass dropped at double the rate of females of the same age [27], explaining why males were more prone to sarcopenia.

In the older adult, BMI may be used as an independent predictor of skeletal muscle mass index and is positively connected with it ($\beta = 0.313$, $R^2 = 0.819$, $p < 0.001$). According to Japanese research, BMI is highly related to skeletal muscle mass index [7]. A low BMI was connected with a greater likelihood of a low skeletal muscle mass index [21]. The results of this research were similar to the findings of the previous investigations, which all concluded that the skeletal muscle mass index was positively connected with BMI [28]. This research discovered that BMI (*OR* = 0.193, $p < 0.001$) was a protective factor for sarcopenia. Moderate increases in BMI have been proven in studies to lessen the incidence of sarcopenia in older adults [22] [25]. Body mass index (BMI) and skeletal muscle mass index (SMMI) were considerably lower in the sarcopenia group than in the non-sarcopenia group [29]. The findings of this investigation support these conclusions. However, research conducted in the United States found that the proportion of people with impaired muscle function rose with increasing body mass index [30], which contradicted this study's findings. One potential explanation is that people with poor muscle function and limited action ability were eliminated from the included population in this experiment. Consequently, there were no participants with impaired muscular function, resulting in the opposite outcomes of this research in the United States.

Fat mass ($\beta = -0.116$, $R^2 = 0.819$, $p < 0.001$) may be used as an independent predictor of sarcopenia. The research found a negative relationship between skeletal muscle mass index and overall fat mass [8]. Studies have indicated that myostatin expression is connected with intramuscular fat ($r = 0.29$, $p < 0.05$) in the middle thigh, [26] increasing intramuscular fat in the middle thigh would increase myostatin expression, so further lowering muscle mass; this might explain the results of this research.

Sarcopenia is associated with increased fat accumulation (*OR* = 1.952, 95% *CI*: 1.769 - 2.154, $p < 0.001$). Fat mass was shown to be a risk factor for sarcopenia. Some researchers suggest that increasing total fat might cause muscle fat formation by boosting pro-inflammatory cytokines, resulting in a negative relationship between fat level and skeletal muscle quality [31]. In a study of 3075 people, it was found that too much body fat was associated with too little muscle mass [32]. According to certain research, fat loss predicts muscle function better than defatted muscle loss [33]. A higher body fat percentage is linked to a greater risk of skeletal muscle loss [21].

Sarcopenia is caused by a combination of factors, including insulin resistance, inflammation, oxidative stress, and hormonal abnormalities [34]. Many studies have shown a link between muscle cytokine production and muscular contraction. Thus, compared to young individuals, older adults who do not exercise may have cytokine imbalances that contribute to a pro-inflammatory state and metabolic dysfunction, increasing important cascades of muscle loss and fat gain [35]. The increased fat mass may worsen sarcopenia because persistent lipid accumulation impairs amino acid binding and muscle protein synthesis [36]. Previous research found a negative trend in fat mass in sarcopenia patients, with female sarcopenia individuals decreasing more considerably, which contradicted the findings of this study [37]. This result could be attributed to the subjects' different races [38], regions, or lifestyles.

Total energy metabolism in the older adult may be used as an independent predictor of skeletal muscle mass index and is positively connected with it ($\beta = 0.001$, $R^2 = 0.819$, $p < 0.001$). Because basic metabolism and total energy metabolism are collinear, the link between basic metabolism and total energy metabolism and skeletal muscle mass index is likewise positively associated. This study focuses on just one of them. The research findings on whole-body energy metabolism and biochemical features of skeletal muscle reveal that differences in muscle biochemistry contribute to the diversity in muscle oxygen uptake and whole-body energy metabolism across people (metabolic rate and substrate oxidation) [39]. Muscle tissue helps in energy metabolism [40]. Its increased skeletal muscle mass enhances the hydrolysis of triglyceride-rich lipoproteins by boosting the lipoprotein lipase (LPL) and high-density lipoprotein binding protein 1 (GPIHBP1) cycles, hence enhancing energy metabolism [41]. Consequently, the skeletal muscle mass index is substantially connected with the basal metabolic rate ($r = 0.72$, $\beta = 30.96$, $p < 0.01$) [9], which is consistent with the findings of this research.

Total energy metabolism is lower in sarcopenia patients than in non-sarcopenia patients. This shows that energy metabolism can predict and prevent sarcopenia. In a clinical study of 22 adults aged 65 years or older, the decreased ability of skeletal muscles to regulate energy expenditure to meet basic physical energy requirements may explain the muscle strength and physical limitations associated with sarcopenia [42]. Another rhesus monkey research discovered that alterations in energy metabolism directly cause skeletal muscle aging [43]. Similarly, research on overweight persons revealed that abnormalities in energy metabolism may result in muscle integrity loss [44]. Oxidative modification damages energy metabolism, which accelerates muscle satellite cell ageing and damage, which could explain this experiment's results [45]. However, research on linked illnesses revealed that hypermetabolism could result in a loss of muscle mass, which contradicted the results of this trial [46]. It is possible that none of the participants in this study had hypermetabolism.

## 5. Conclusion

The prevalence rate of sarcopenia climbed with age and was higher in Zhuang than in other ethnic groups in China. Male participants had a substantially greater frequency of sarcopenia than female participants. Sarcopenia Zhuang's ageing population had reduced fat mass, basal metabolism, and total energy metabolism.

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## Ethical Standards

This study complied with the Declaration of Helsinki and was approved by the Ethics Committee of Ethics Review Committee of Youjiang Medical University for Nationalities (ethics approval number: 2022053001). All persons gave their informed consent prior to their inclusion in the study.

## Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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