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Research Article

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# Factors Influencing Age-Related Loss of Skeletal Muscle Mass in Young Korean Men

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**| Abstract |**

**PURPOSE:** This study aimed to identify the clinical factors that contribute to age-related loss of skeletal muscle mass (ALSMM) among young Korean male adults.

**METHODS:** This was a cross-sectional study involving 955 men aged between 20-29 years. They underwent screening to assess the ALSMM. The study examined a variety of factors, including age, height, weight, body mass index (BMI), waist circumference (WC), skeletal muscle mass index (SMI), lifestyle-related habits such as smoking and drinking status, systolic and diastolic blood pressure (SBP/DBP), fasting blood glucose (FBG) levels, as well as the serum triglyceride and total cholesterol (TC) levels.

**RESULTS:** The variables that displayed significant associations with ALSMM were height, weight, BMI, WC, SMI, FBG, TC, DBP, and alcohol consumption ($p < .05$). Serum triglyceride levels, SBP, and smoking status did not exhibit statistical significance ($p > .05$).

**CONCLUSION:** The study identified the contributing factors associated with the ALSMM in community-dwelling young adult males. These findings would enrich the current body of literature on ALSMM and provide potential risk factors associated with its development in young Korean males.

**Key Words:** Age-related loss of skeletal muscle mass, Influencing factor, Young Korean men

## Ⅰ. Introduction

The degenerative reduction of muscle mass associated with aging is a prevailing health concern [1]. The age-related loss of skeletal muscle mass (ALSMM) correlates with several detrimental consequences, including falls, fractures, physical impairment, metabolic disorders, a decline in life quality, and elevated mortality.

The elderly population in Asia, particularly in Korea, is experiencing rapid growth. In 2021, roughly 16.5% of Korea's populace was aged 65 years or older, and the proportion of the elderly population is anticipated to soar to 39.8% by 2050 [2]. This demographic shift is expected to have a more profound impact on Korea and Asia

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compared to other countries, because of age-related conditions, including ALSMM.

Moreover, the loss of skeletal muscle mass appears to be more common in men than in women. In a previous study, Brown et al. [4] observed ALSMM in 4,425 adults in the United States, noting a higher occurrence among males in comparison to females [3]. Similarly, Liu et al. in a study involving 4,500 individuals in a Chinese urban community found the prevalence to be 22.1% in men and 17.8% in women [4]. Hai et al. in their evaluation of 834 community-dwelling Chinese individuals, reported an incidence of 11.3% in men and 9.8% in women [5]. Additionally, Chan et al. found a prevalence of 9.30% in males and 5.30% in females in their study of 3,957 individuals in Hong Kong [6]. A Korean young old elderly population study demonstrated a greater prevalence of ALSMM in males than in females, at 41.2%, and 37.2%, respectively [7]. These investigations collectively suggest a higher prevalence of ALSMM in males compared to females.

Although a considerable population of older adults and a higher proportion of males are susceptible to ALSMM, challenges persist in identifying the contributing factors and identifying early predictors to prevent ALSMM. This is due to the dearth of investigation of ALSMM among males, in contrast to the extensively studied research on this condition in females [8-11].

Furthermore, the majority of research on ALSMM has centered on individuals aged 30 years and above [7,12-19]. Recognizing the contributing factors among men aged 20 to 29 years is critical for formulating early preventive strategies against age-related muscle loss. Hence, this investigation aimed to identify the specific clinical contributing factors in young Korean men aged 20 to 29 years. The premise of this study was that men in their 20s possess distinct contributing factors associated with skeletal muscle mass loss.

## Ⅱ. Methods

### 1. Study Population Included in the Study

The current investigation utilized data from the Korea National Health and Nutrition Examination Survey (KNHANES), conducted by the Korea Disease Control and Prevention Agency (KDCA) to monitor the health-risk behaviors of the population. Employing a stratified, clustered, multistage probability sampling design, a total of 37,753 individuals participated in the survey from 2008 to 2011. Out of these, 36,306 individuals were excluded, as they were either below 20 or above 29 years old, leaving 1,447 subjects for probable inclusion in this study. Subsequently, a further 492 subjects were excluded because the data on their health surveys and dual-energy X-ray absorptiometry (DEXA) measurements were unavailable. Consequently, data from 955 male participants between the ages of 20 and 29 years were considered in the final analysis. The study's inclusion criteria were male individuals between 20 and 29 years old, while the exclusion criteria encompassed individuals lacking DEXA measurements and health survey data and those who had been hospitalized for any reason. Among the final study subjects, 24 individuals were categorized into the ALSMM group based on their skeletal muscle mass index (SMI), while the remaining 931 individuals were included in the normal group. Approval for the study was obtained from the institutional review board of the KDCA (approval numbers 2008-04EXP-01-C, 2009-01CON-03-2C, 2010-02CON-21-C, and 2011-02CON-06-C), with informed written consent acquired from all participants. Additional specifics are delineated in Table 1.

### 2. Variables Evaluated for Association with ALSMM

The research analysis encompassed several variables, including age, height (measured in centimeters), weight (measured in kilograms), body mass index (BMI), waist

Table 1. Clinical factors associated with age-related loss of skeletal muscle mass

| (N=955) | ALSMM ($n$ = 24) | Normal ($n$ = 931) | $p$ |
|---|---|---|---|
| Age (years) | 26.41 ± 1.81 | 25.11 ± 2.66 | .018* |
| Height (cm) | 164.97 ± 5.57 | 174.75 ± 5.39 | .000** |
| Weight (kg) | 77.19 ± 14.16 | 72.05 ± 11.80 | .036* |
| BMI ($kg/m^2$) | 28.21 ± 4.02 | 23.56 ± 3.53 | .000** |
| WC (cm) | 90.58 ± 10.89 | 80.92 ± 9.39 | .000** |
| SMI ($kg/m^2$) | 748.72 ± 39.15 | 1033.52 ± 114.57 | .000** |
| FBG (mg/dL) | 93.65 ± 12.53 | 88.44 ± 9.46 | .010* |
| Triglyceride (mg/dL) | 166.52 ± 138.77 | 121.33 ± 117.01 | .069 |
| TC (mg/dL) | 185.69 ± 40.38 | 172.34 ± 31.57 | .047* |
| SBP (mmHg) | 118.20 ± 16.78 | 114.62 ± 10.65 | .111 |
| DBP (mmHg) | 81.20 ± 14.56 | 76.44 ± 9.51 | .017* |
| Drinking status (%) (current-/ex-/non-drinkers) | 82.17 / 13.09 / 4.73 | 94.24 / 3.35 / 2.40 | .007** |
| Smoking status (%) (current-/ex-/non-smokers) | 59.04 / 8.46 / 32.49 | 72.56 / 3.09 / 24.33 | .349 |

• ALSMM, age-related loss of skeletal muscle mass; BMI, body mass index; WC, waist circumference; SMI, skeletal muscle mass index SBP, systolic blood pressure; DBP, diastolic blood pressure; FBG, fasting blood glucose; TC, total cholesterol. $p < .05$ *, $p < .01$ **

circumference (WC), skeletal muscle index (SMI), fasting blood glucose (FBG) levels, triglycerides, total cholesterol (TC), systolic and diastolic blood pressure (SBP/DBP), smoking and drinking status. WC was measured by determining the circumference at the mid-point between the bottom of the ribcage and the top of the iliac crest during full expiration. Blood tests were performed after an eight-hour fasting period, while SBP and DBP were measured using a mercury sphygmomanometer after a ten-minute seated rest. The subjects were classified as non-users, ex-users, or current users based on their smoking and drinking status.

### 3. Diagnosis of ALSMM

Diagnosing ALSMM, identified by the ICD-10-CM code M62.84, involves assessing the skeletal muscle mass in the limbs. The study employed DEXA, specifically utilizing the QDR4500A equipment from Hologic, Inc. in Bedford, MA, to measure limb muscle mass. The Skeletal Muscle Mass Index (SMI) was computed by evaluating the ratio of Appendicular Skeletal Muscle Mass (ASM) in kilograms to Body Mass Index (BMI) in kilograms per square meter, offering an assessment of skeletal muscle mass. ALSMM was diagnosed when the SMI value was below .789 for men and under .521 for women, following the criteria established by the Foundation for the National Institutes of Health (FNIH) Sarcopenia Project [20]. The methodology used in this study accurately identified ALSMM among the participants.

### 4. Data Analysis

Statistical analysis was performed using the SPSS version 22.0 software. (IBM Corp., Armonk, NY) To accommodate the complex sampling design of KNHANES, weights were applied during the analysis. The data adopted a stratified, clustered, multistage probability sampling design. Independent t-tests and Chi-square analyses were utilized to compare the clinical parameters between participants with and without ALSMM. Multiple logistic regression was employed to ascertain the odds ratio of ALSMM. The statistical significance level was set at p = .05.

## Ⅲ. Results

### 1. Factors Contributing to the Development of ALSMM

Statistically, the variables that demonstrated significance (p < .05) were height, weight, BMI, WC, SMI, FBG, TC, and DBP, as well as drinking status. Conversely, the variables triglycerides, SBP, and smoking status did not show statistical significance (p > .05) (Table 1).

Table 2. Odds ratio for variables associated with the age-related loss of skeletal muscle mass

| Variables | OR (95% Confidence interval) | *p* |
|---|---|---|
| Height | .786 (.040–.896) | .034* |
| Weight | 1.599 (1.126-2.633) | .027* |
| BMI | 1.224 (1.070–1.786) | .005** |
| WC | 2.680 (1.732–4.146) | .047* |
| SMI | .015 (.010–.028) | .000** |
| DBP | 1.296 (1.055–1.475) | .042* |
| FBG | 1.052 (1.003–1.148) | .046* |
| TC | 1.031 (1.080–1.213) | .048* |

• BMI, body mass index; WC, waist circumference; SMI, skeletal muscle mass index; DBP, diastolic blood pressure; FBG, fasting blood glucose; TC, total cholesterol.

• Odds ratio (OR) values are present as the 95% confidence interval (CI)

p < .05 *, p < .01 **

### 2. Multiple Logistic Regression for Odds Ratio

Table 2 presents the odds ratios (OR) along with a 95% confidence interval (CI) for the presence of ALSMM in males, obtained through multiple logistic regression analysis. Notably, the factors identified as statistically significant (p < .05) are listed as follows: height .786 (.040–.896), weight 1.599 (1.126-2.633), BMI 1.224 (1.070–1.786), WC 2.680 (1.732–4.146), SMI .015 (.010–.028), DBP 1.296 (1.055–1.475), FBG 1.052 (1.003–1.148), and TC 1.031 (1.080–1.213).

## Ⅳ. Discussion

This study examined the factors contributing to ALSMM among community-dwelling young male individuals aged between 20 and 29 years. The WC, SMI, FBG, TC, and DBP, as well as drinking status were found to be risk factors for muscle loss.

WC is a significant risk factor in the context of age-related muscle loss. Multiple studies have consistently demonstrated an association between WC and a heightened risk of ALSMM in men [3,21,22]. Brown et al. conducted a study within a US cohort and identified WC as a contributing factor for ALSMM, reporting an OR of 1.39 (with a 95% CI: 1.05–1.84) in men [3]. Similarly, a cohort study in Brazil involving individuals with ALSMM revealed an odds ratio of 17.90 (95% CI: 1.48–201.16) for WC [22]. Furthermore, a study among community-dwelling individuals in Japan indicated that those with ALSMM exhibited larger WC compared to those without ALSMM [21].

The plausible explanation for the higher waist circumferences observed in adults with ALSMM is the interconnected relationship between the increase in fat mass

and the reduction in muscle mass [23]. Individuals with ALSMM commonly experience poor muscle strength and function due to muscle loss, leading to decreased engagement in physical activities. They also experience difficulties in tasks like sitting-to-standing and walking extended distances, both indoors and outdoors [24]. This diminished physical activity is strongly associated with reduced overall daily energy expenditure and an increase in fat deposits, particularly in the visceral and abdominal areas, consequently increasing the WC [24]. Conversely, a higher volume of fat, notably visceral fat, generates pro-inflammatory cytokines such as interleukin (IL)-6 and C-reactive protein (CRP), which can impede the muscle tissue's anabolic response [25]. Hence, the correlation between reduced muscle mass and increased fat mass in ALSMM operates in a bidirectional and mutually reinforcing manner [26].

FBG levels have been recognized as a contributing factor to ALSMM in men, displaying mean values of 107.61mg/dL and 99.50 mg/dL in the ALSMM and normal groups, respectively. This finding aligns with previous research findings [19,27-31]. Lu et al. [27] investigated a cohort of six hundred individuals residing in the community and noted that those within the ALSMM group exhibited higher FBG levels of 110 mg/dL in comparison to 99 mg/dL in the normal group. Bersemi et al. [31] conducted a cohort study involving 150 community-dwelling individuals with ALSMM. The study revealed that this group displayed elevated FBG levels compared to the non-ALSMM group. Similarly, a Turkish study involving 147 participants revealed that individuals with ALSMM encountered challenges in managing their blood glucose levels [28]. Hwang et al. [19] investigated 2,692 Korean community-dwelling young old adults and concluded that the male old population had higher blood glucose levels compared to the normal population.

The potential theoretical explanation for the increased fasting glucose levels in individuals with ALSMM revolves around the role of muscle mass in regulating postprandial glucose levels. Skeletal muscle plays a critical role in storing approximately 80% of consumed glucose following meals to prevent high blood sugar levels [32]. Individuals with ALSMM, especially males, often exhibit reduced sensitivity to insulin, resulting in decreased glucose uptake by the skeletal muscles. This can be attributed to lower proportions of type I muscle fibers and reduced capillary density, both of which reduce the response to insulin [33]. Consequently, the diminished skeletal muscle mass and compromised insulin sensitivity in males with ALSMM may contribute to reduced uptake of glucose by muscles from the bloodstream, leading to an increase in blood glucose levels.

The findings of our study emphasize that higher total cholesterol levels are a contributing factor to the onset of ALSMM in men, which is consistent with earlier studies [21,34]. For example, Du et al. [21] observed that men within the ALSMM group displayed increased total cholesterol levels compared to those in the normal group. Similarly, in a study involving 1488 Japanese individuals by Sanada and colleagues [34], individuals diagnosed with ALSMM exhibited notably elevated total cholesterol levels in comparison with the normal group [29].

The potential reason for the higher total cholesterol levels in ALSMM might be associated with factors such as insulin resistance [35] and an increased presence of inflammatory cytokines [34,35]. These factors have the potential to disrupt lipid metabolism, leading to higher triglyceride and total cholesterol levels in individuals affected by ALSMM. Overall, the study consistently underlines the significance of increased total cholesterol levels as a contributing factor to the development of ALSMM in men, thus aligning with earlier study outcomes [36].

Alcohol consumption has been identified as a risk factor for age-related muscle loss, consistent with earlier research [37,38]. Pang et al. conducted a study involving 542 Singaporean community-dwelling adults, establishing a strong connection between alcohol consumption and

ALSMM [38]. Similarly, Daskalopoulou et al., in a multicenter population-based study comprising 8694 individuals, also emphasized that alcohol consumption is one of the risk factors for ALSMM [37]. A Korean ALSMM study of 1,564 middle-aged subjects identified drinking status as a risk factor for ALSMM [15].

The underlying mechanism behind the association between alcohol consumption and ALSMM can be explained as follows: alcohol has an adverse effect on protein synthesis, the process vital for the body in building muscle. This impact can result in a reduction in both muscle mass and strength over time [39]. Additionally, alcohol can disrupt the body's ability to absorb crucial nutrients, such as protein and amino acids, necessary for muscle growth and repair. Moreover, alcohol consumption can induce dehydration, further hindering muscle function and recovery [40].

Our findings demonstrate that diastolic blood pressure (DBP) is an additional risk factor for men, consistent with prior studies focused on this demographic [15,27,41-43]. In a British cohort study involving 4,252 participants with ALSMM, Atkins et al. found significantly higher DBP in the ALSMM group compared to the normal group [41]. Similarly, in a U.S. cohort study by Androga et al. [42]. a higher prevalence of hypertension was reported in the ALSMM group compared to the normal group [44-46]. Additionally, Yin et al.'s study involving 14,926 Chinese individuals noted significantly elevated DBP in males affected by ALSMM compared to normal adults [43]. Hwang and Park explored the clinical risk factors for ALSMM in men between the ages of 40 and 49 years, wherein DBP was identified as a significant influencing factor [15]. Potential mechanisms explaining the elevated DBP in men with ALSMM include metabolic changes and loss of muscle mass due to reduced energy expenditure and physical activity, contributing to insulin resistance and arterial stiffness [36-38]. Furthermore, the accumulation of visceral fat mass might incite an inflammatory response, leading to thickening of blood vessel walls, constriction of vascular passages, and the hindrance of blood flow [47].

One significant aspect of this study was the exploration of male-specific risk factors in the representative sample of Korean young adults. This differs from the more common approach that combines both genders into a single group [3,48,49]. However, it is important to note a limitation in this study for consideration in future research. The study's use of a cross-sectional design, despite its inclusion of a substantial and representative sample of 955 participants through statistical weighting, might limit the ability to establish causal relationships for the identified influencing factors. Thus, for stronger and more conclusive findings, upcoming studies should consider utilizing a longitudinal or randomized case-control study design.

## Ⅴ. Conclusion

The current study investigated clinical evidence highlighting the risk factors for ALSMM in young male adults. The study's findings suggest that specific clinical factors, including height, weight, BMI, WC, SMI, FBG, triglycerides, DBP, and alcohol consumption status, might elevate the probability of developing ALSMM in young men. These outcomes enrich the current understanding of ALSMM, shedding light on potential risk factors that correlate with the emergence of this condition in young male adults. Further longitudinal investigation is essential to better understand the underlying mechanisms and to devise specific interventions for individuals at risk of ALSMM.

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