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Research Article

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Potential Predictive Indicators for Age-Related Loss of Skeletal Muscle Mass in Community-Dwelling Middle-Aged Women

Jongseok Hwang, PT, PhD†

Sarcopenia Research Center, Institute of Human Ecology & Kinesiology, Yeungnam University

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| **Abstract** |

PURPOSE: This study aimed to identify the potential clinically predictive indicators of the age-related loss of skeletal muscle mass (ALSMM) in middle-aged women.

METHODS: The data from a cross-sectional study involving 2,066 community-dwelling female participants aged 40 to 49 years were analyzed. Complex sampling analyses were used to ensure a nationally representative analysis, incorporating the individual weights provided by KNHANES. This approach accounted for the stratified, clustered, and multistage probability sampling design of the survey. The participants were screened for ALSMM, and various potential predictive indicators were assessed, including age, height, weight, body mass index, waist circumference, skeletal muscle mass index, smoking and drinking status, systolic and diastolic blood pressure, fasting glucose levels, triglyceride levels, and cholesterol levels.

RESULTS: Significant potential predictive indicators for ALSMM included height, weight, body mass index, waist circumference, skeletal muscle mass index, and fasting glucose ($p < .05$). The systolic blood pressure, diastolic blood pressure, triglyceride levels triglyceride, and drinking and smoking status were found to be non-significant variables ($p > .05$).

CONCLUSION: The study identified the potential predictive indicators for ALSMM among community-dwelling middle-aged women. These findings enhance the current understanding of ALSMM and highlight the potential predictive indicators associated with its development in middle-aged women.

Key Words: Age, Muscle Loss, Odds ratio, Potential predictive indicator

Ⅰ. Introduction

Progressive skeletal muscle mass reduction with age is a major health concern [1]. The age-related loss of skeletal muscle mass, known as ALSMM, can give rise to multiple detrimental outcomes, including increased susceptibility to falls and fractures, heightened risk of physical disability, disturbances in metabolic function, a decline in overall quality of life, and elevated mortality rates.

†Corresponding Author : Jongseok Hwang
sfcsfc44@naver.com, https://orcid.org/0000-0003-3376-5619

The global aging population is increasing rapidly, with Korea being one of the fastest-aging nations globally. By 2021, approximately 16.5% of Korea's population was aged 65 or older, a proportion projected to soar to 40% by 2050 [2]. Consequently, age-related conditions, such as ALSMM, are expected to exert a more substantial influence on Korea and the broader Asian region compared to other nations.

Moreover, numerous studies have indicated a higher prevalence of ALSMM among females compared to males. For example, Dam et al. screened 10,063 individuals and observed ALSMM in 11.80% and 5.10% of women and men, respectively [3,4]. Similarly, Hunt et al. examined 1,921 Japanese community-dwelling individuals and reported ALSMM rates of 16.56% and 10.34% in females and males, respectively [5].

A significant portion of the older adult population, particularly females in Korea, is at risk of ALSMM. Nevertheless, identifying and detecting ALSMM in female patients early on remains a formidable challenge, especially compared to the extensive research conducted on ALSMM in males [5-8]. Despite the increasing prevalence of ALSMM in elderly females and its potential adverse outcomes, healthcare professionals, including physical therapists and primary care clinicians, encounter difficulties in diagnosing ALSMM because of insufficient knowledge and diagnostic tools. Given the limited time available per patient visit, primary care clinicians must assess the likelihood of ALSMM in patients before considering referral for further diagnosis and treatment. In addition, a lack of awareness of ALSMM as a distinct disease among clinicians heightens the risk of overlooked diagnoses [9]. Effectively addressing this challenge necessitates a comprehensive understanding of the characteristics of critical potential predictive indicators associated with early detection and prevention [10]. The timely identification of symptomatic individuals is crucial because it greatly enhances early diagnosis and intervention. Delayed or missed diagnoses can result in serious complications, such as reduced functional recovery, lower quality of life, and inefficient use of healthcare resources. Early detection ensures that patients receive appropriate care promptly, minimizing the risk of these adverse outcomes and promoting better overall health management. By prioritizing the early identification of symptoms, healthcare systems can optimize resource allocation and improve patient prognosis, leading to more effective and efficient care delivery.

Despite most ALSMM research concentrating on individuals aged 50 and above [11-14], age-related muscle decline can start as early as 40 years [15-19]. Identifying the potential early indicators of muscle loss is essential for effective prevention and treatment. The early recognition of these predictive signs enables timely intervention, which can mitigate the progression of muscle deterioration. By addressing muscle loss in its initial stages, healthcare providers can implement strategies to preserve muscle function, enhance patient mobility, and improve the overall quality of life. Moreover, early detection allows personalized treatment plans to prevent further complications, optimize recovery, and promote better long-term health outcomes [20-37]. Therefore, the current study examined the potential predictive indicators for ALSMM among middle-aged women aged 40 to 49. The study hypothesizes that distinct potential predictive indicators are specific to this age cohort.

Ⅱ. Methods

1. Dataset

The study used data from the Korea National Health and Nutrition Examination Surveys by the Centers for Disease Control and Prevention to monitor population health-risk behaviors. Data collection used a stratified, clustered, multistage probability sampling method. Among the 37,753 individuals surveyed between 2008 and 2011, 34,123 were excluded based on age criteria, resulting in a final participant count of 3,630. In addition, 1,574 subjects were excluded because of insufficient data availability,

leaving 2,056 participants aged between 40 and 49 years for analysis. These participants were divided into two groups according to their skeletal muscle mass index score, with 18 individuals categorized as having ALSMM and the remaining 2,048 individuals considered normal.

The study received approval from the institutional review board of the Center for Disease Control and Prevention under approval numbers 2008-04EXP-01-C, 2009-01CON-03-2C, 2010-02CON-21-C, and 2011-02CON- 06-C, and written informed consent was obtained from all participants.

2. Research Variables

The study encompassed various variables, including age, height (measured in centimeters), weight (measured in kilograms), body mass index (BMI), waist circumference (WC), skeletal muscle index (SMI), smoking and drinking habits, fasting glucose levels, triglycerides, total cholesterol (TC), and systolic and diastolic blood pressure measurements. The WC was determined by measuring the circumference midway between the bottom of the ribcage and the top of the iliac crest during full expiration. Blood tests were conducted after an eight-hour fast, while the systolic and diastolic blood pressures were measured using a mercury sphygmomanometer following a ten-minute rest in the seated position. The smoking and drinking statuses were categorized as non-users, ex-users, or current users.

3. Criteria for ALSMM

The criteria for diagnosing ALSMM involve measuring the skeletal muscle mass in the limbs, classified under ICD-10-CM code M62.84. The researchers used Dual X-ray Absorptiometry (DXA) with the QDR4500A device from Hologic, Inc., Bedford, MA, to determine the skeletal muscle mass in the limbs [38]

The determination of cut-off points relies on the measurement technique used and the availability of pertinent reference studies. The European Working Group on ALSMM in Older People (EWGSOP) suggests using normative data from healthy young adults instead of other predictive reference populations based on the Rosetta study in ALSMM [39-41]. These cut-off points were established at two standard deviations below the mean reference value, providing a standardized approach to assess ALSMM accurately. The muscle mass involved was evaluated by computing the Appendicular Skeletal Muscle Mass (ASM) divided by the square of height, a metric often referred to as the Skeletal Muscle Mass Index (SMI)

4. Data Analysis

Data analysis involved examining the statistical values for each measurement, such as the mean and standard deviation. Complex sampling analyses were applied to ensure a representative analysis on a national scale, incorporating individual weights provided by KNHANES. Statistical analyses were conducted using SPSS 22.0 software (IBM Corporation, Armonk, NY, USA), considering the stratified, clustered, multistage probability sampling design of the survey. Independent t-tests and chi-square analyses were used to compare the chemical parameters of the ALSMM and non-ALSMM participants. Furthermore, multiple logistic regression was used to calculate the odds ratio of ALSMM. The significance level for all statistical tests was set at $p = .05$.

Ⅲ. Results

1. Clinical Potential Predictive Indicators

The height, weight, BMI, WC, SMI, and fasting glucose were statistically significant ($p < .05$). In contrast, the TC, triglycerides, systolic blood pressure, diastolic blood pressure, drinking status, and smoking status were not statistically significant ($p > .05$) (Table 1).

2. Odds Ratio for ALSMM

Table 2 lists the odds ratios and 95% confidence intervals (CI) for ALSMM in females based on multiple logistic

Table 1 Clinical risk factors associated with ALSMM

	ALSMM (n = 18)	Normal (n = 2048)	p
Age (years)	44.11 ± 2.94	44.46 ± 2.96	.616
Height (cm)	154.18 ± 7.41	157.94 ± 5.27	.003
Weight (kg)	45.51 ± 4.27	58.66 ± 8.73	.000
BMI (g/m^2)	19.18 ± 1.80	23.51 ± 3.26	.000
WC (cm)	69.02 ± 5.50	77.76 ± 8.78	.000
SMI (g/m^2)	4311.15 ± 138.85	5969.31 ± 734.64	.000
FG (mg/dL)	124.37 ± 79.61	94.33 ± 19.07	.000
Triglyceride (mg/dL)	88.23 ± 50.84	107.03 ± 77.72	.320
TC (mg/dL)	199.76 ± 56.23	185.98 ± 32.12	.081
SBP (mmHg)	107.33 ± 16.27	112.67 ± 14.68	.125
DBP (mmHg)	70.16 ± 12.18	74.53 ± 10.03	.067
Drinking status (%)(current-/ex-/non-smoker	90.94 / 0.00 / 9.05	74.69 / 13.43 / 11.87	.286
Smoking status (%) (current-/ex-/non-smoker)	19.81 / 0.00 / 80.18	7.36 / 2.11 / 90.52	.183

Values are expressed as the mean ± standard deviation. The independent t-test and chi-square test were used to compare the two groups.
ALSMM, age-related loss of skeletal muscle mass; BMI, body mass index; WC, waist circumference; SMI, skeletal muscle mass index; FG, fasting glucose; TC, total cholesterol; SBP, systolic blood pressure; DBP, diastolic blood pressure.

Table 2. Multiple logistic regression for odds ratios of ALSMM

Variables	Odds ratio (95% of CI)	p
Height	.850 (.832–.868)	.034
Weight	.565(.315–.862)	.000
Waist circumference	.854(.639–.958)	.008
Fast glucose	2.527(1.357–3.548)	.000

Odds ratio values are present as the 95% confidence interval (CI) Multiple logistic regression was exploited.

regression analysis. Significant variables ($p < .05$) include height with an odds ratio of .850 (CI: .832–.868), weight with an odds ratio of .565 (CI: .315–.862), waist circumference (WC) with an odds ratio of .854 (CI: .639–.958), and fasting glucose with an odds ratio of 2.527 (CI: 1.357–3.548).

Ⅳ. Discussion

This study examined the potential predictive indicators of community-dwelling middle-aged female individuals aged between 40 and 49 years. In addition, the height, weight, BMI, WC, SMI, and fasting glucose were potential predictive indicators for ALSMM.

Anthropometric measures, particularly waist circumference and weight, are potential predictive indicators of ALSMM. Several studies have reported that increased waist circumference and weight are potential predictive indicators of ALSMM. [32,42,43] A Korean nationwide study reported that the weight in the ALSMM group was smaller than the normal group [32]. Similarly, Kim [42] investigated 1,946 community-dwelling older people. They concluded that the ALSMM group had a smaller weight and torso body fat mass.

Qianyun Zhao [43] investigated 165 patients in China and reported that the ALSMM group had a significantly smaller waist circumference and weight. Several underlying reasons explain why individuals with sarcopenia tend to have smaller waist circumferences and lower body weight.

ALSMM is characterized by the progressive loss of skeletal muscle mass and strength. The muscle tissue is denser and heavier than fat tissue, so a reduction in muscle mass leads to an overall decrease in body weight [44]. In addition to muscle loss, ALSMM individuals often experience a decrease in subcutaneous and visceral fat. This contributes to a smaller waist circumference. As muscle mass decreases, the ability of the body to store fat efficiently also diminishes, leading to lower fat deposits around the waist [44]. ALSMM is associated with metabolic changes that affect the energy expenditure and fat storage of the body. Reduced muscle mass lowers the basal metabolic rate, altering how the body processes and stores fat, often leading to a trimmer waistline [45]. Poor nutrition and insufficient protein intake are common in older adults and can exacerbate muscle loss. Inadequate nutrition leads to reduced muscle mass and contributes to overall weight loss and decreased waist circumference because of insufficient caloric intake to maintain body weight [46]. In summary, smaller waist circumference and reduced body weight in individuals with sarcopenia were attributed to the loss of muscle mass and strength, decreased fat storage, and altered metabolism. Poor nutrition and insufficient protein intake further contribute smaller weight and waist circumference.

The fasting glucose levels have been identified as a potential predictive indicator for ALSMM in females, with average values of 107.61 mg/dL and 99.50 mg/dL in the ALSMM and normal groups, respectively. These findings are consistent with previous research [47-51]. Lu et al. [47] examined 600 community-dwelling individuals and reported elevated fasting blood glucose levels of 110 mg/dL (6.1 mmol/L) in the ALSMM group compared to 99 mg/dL (5.4 mmol/L) in the normal group. Bersemi et al. [51] conducted a cohort study on 150 community-dwelling individuals with ALSMM and reported higher fasting glucose levels in the ALSMM group compared to the non-ALSMM group. A Turkish study involving 147 participants also suggested that ALSMM patients had difficulties controlling their blood glucose levels [48]. A plausible theoretical mechanism for the elevated fasting glucose levels in ALSMM individuals is the role of muscle mass in regulating the postprandial glucose levels. The skeletal muscle stores approximately 80% of ingested glucose after meals, preventing hyperglycemia [17]. ALSMM patients, particularly females, often exhibit reduced insulin sensitivity, leading to decreased glucose uptake by skeletal muscles. This reduced sensitivity may be due to the lower proportions of type I muscle fibers and capillary density, which are less responsive to insulin [52]. Consequently, the decreased skeletal muscle mass and compromised insulin sensitivity in females with ALSMM contribute to reduced glucose uptake by muscles from the bloodstream, leading to elevated blood glucose levels.

A virtue of the present research is its investigation of the predictive indicators, specifically in females within a representative population aged 40–49 years, an age group that has begun to experience a decline in skeletal muscle mass [33-36]. These findings facilitate the early detection and treatment of ALSMM.

On the other hand, the current study had several limitations that should be considered for future research. First, the cross-sectional design, despite including a substantial sample size of 2,055 participants representative of the entire population through statistical weighting, may have limited the ability to establish the causal relationships for the identified predictive indicators. For example, although elevated glycemia, triglycerides, and total cholesterol levels may predict ALSMM, ALSMM itself might cause higher levels of these blood markers. Thus, further research will be needed to understand the relationship between these predictors and ALSMM. Future

studies can use longitudinal or randomized case-control study designs to enhance the robustness of the findings. Next, although there was no statistical significance in the blood pressure and triglyceride levels, the ALSMM group exhibited lower values than the Normal group. This intriguing finding warrants further investigation into the underlying mechanisms and potential clinical implications. Finally, although complex sample analysis minimized numerous statistical errors, discrepancies in sample sizes between the two groups may still introduce statistical inaccuracies. Future research should use comparable sample sizes across groups to address this issue effectively.

Ⅴ. Conclusion

This paper reported a groundbreaking analysis of the clinical potential predictive indicators linked to ALSMM in females in their 40s. The study highlights several potential predictive indicators of ALSMM, including height, weight, body mass index, waist circumference, and fasting glucose levels. Understanding these factors will enable healthcare professionals to identify and diagnose the potential cases of ALSMM. Future research should further explore the relationships between these predictors and ALSMM through longitudinal or randomized case-control study designs to strengthen and confirm these findings.

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