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Research Article

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Distribution Dynamics and Proposed Determinants: Exploring Morphological, Clinical Laboratory, and Lifestyle Factors in the Coexistence of Age-Related Skeletal Muscle Mass Loss and Obesity among Young Men: A Nationwide Cross-Sectional Study

Jongseok Hwang, PT, Ph.D.†
Institute of Human Ecology, Yeungnam University

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| Abstract |

PURPOSE: This study examined the distribution dynamics and proposed determinants, including morphological measurements, clinical laboratory tests, and lifestyle factors among young Korean men aged 20 to 29 years with the coexistence of age-related loss of skeletal muscle mass and obesity (CALSMO).

METHODS: Six hundred and sixty-six participants were divided into two groups based on their skeletal muscle mass index, with 12 individuals categorized in the CALSMO group and the remaining 654 in the normal group. The proposed determinants variables consisted of three main components: morphological measurements, clinical laboratory tests, and lifestyle factors. The morphological measurement variables were height, weight, body mass index, waist circumference, and skeletal muscle mass index. The clinical laboratory tests were fasting glucose, triglyceride, total cholesterol levels, and systolic and diastolic blood pressure. The lifestyle factors considered were alcohol consumption and tobacco use. Complex sampling analysis was performed for the evaluation.

RESULTS: The distribution dynamics were determined to be 1.81(1.02-3.18) %. Morphological factors, such as height, weight, body mass index, waist circumference, and skeletal muscle mass index, showed significant differences ($p < .05$). The clinical laboratory test variables, specifically the fasting glucose, triglyceride, and total cholesterol levels, also exhibited significant differences ($p < .05$). The lifestyle factor, alcohol consumption, also showed a significance ($p < .05$).

CONCLUSION: This study provides insights into the distribution dynamics. The proposed determinants in young Korean individuals with CALSMO are height, weight, body mass index, waist circumference, skeletal muscle mass index, fasting glucose, triglyceride, total cholesterol levels, and alcohol consumption.

Key Words: Aging, Muscle wasting, Obesity, Predictive factors, Prevalence

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

Ⅰ. Introduction

Coexisting age-related skeletal muscle mass loss and obesity (CALSMO) manifests when an individual simultaneously has declining skeletal muscle mass caused by aging and obesity, marked by excessive adipose tissue accumulation and resulting in adverse health outcomes. CALSMO presents a substantial health threat because it amalgamates the adverse effects of age-related muscle mass reduction and the associated health complications from obesity [1,2].

Sarcopenia has physical and physiological impacts on the human body. From a physical perspective, it involves the gradual loss of muscle mass, strength, and function, particularly affecting older individuals. This decline contributes to diminished physical performance, increased vulnerability to injuries, and challenges in performing daily activities [3]. Physiologically, sarcopenia alters the body composition, leading to a higher proportion of body fat relative to muscle mass. This shift can decrease metabolic efficiency and insulin resistance and increase the risk of chronic conditions such as diabetes and cardiovascular diseases. In addition, the decline in muscle strength may compromise overall mobility and independence, affecting the quality of life of individuals with sarcopenia [4,5].

The presence of obesity and diminished skeletal muscle mass can have adverse effects on health, exacerbating chronic degenerative conditions, increasing disability, and prolonging hospitalization periods. As a result, this dual condition presents a significant challenge to the sustainability and effectiveness of healthcare systems across primary and secondary care, social support structures, public health initiatives, and policymaking endeavors [6]. Several studies have provided compelling evidence indicating that individuals affected by this condition often experience more severe instances of illness, heightened levels of disability, and elevated mortality rates compared to those grappling with either low muscle mass or obesity alone [7,8]. Furthermore, obesity impedes the development and retention of muscle mass, posing challenges in diagnosing and recognizing its clinical implications [9].

The age-related decline in skeletal muscle mass is more pronounced in males than females [10,11]. Bouchard et al. [12] examined 904 Canadians. They reported that the distribution dynamics of CALSMO were 19% and 11% for men and women, respectively. In a separate investigation within the Framingham study in the United States, Defour et al. [11] analyzed more than 700 individuals and reported an 8% and 4% incidence of CALSMO in men and women, respectively. These findings suggest a greater susceptibility of men to CALSMO as they age. The challenges in identifying the crucial determinants and managing CALSMO in older adults persist, with a specific emphasis on the significant proportion of affected males. The difficulties become evident when comparing existing research on CALSMO in males with the more extensively studied CALSMO in females [13-15].

Despite the significant implications of CALSMO, healthcare professionals and primary care practitioners frequently face challenges due to the absence of essential diagnostic tools and knowledge for its identification. In a typical primary care setting, where general practitioners typically allocate less than ten minutes per patient, the initial step involves recognizing the potential presence of CALSMO in a patient before contemplating a referral for diagnosis and treatment. In addition, the limited recognition of CALSMO as a distinct medical condition among clinicians heightens the risk of overlooking the diagnosis [16]. Therefore, it is essential to comprehend the key proposed determinants essential for early detection and prevention. The early identification of CALSMO is paramount for recognizing symptomatic patients at the earliest feasible stage [17]. Any delay or failure in diagnosing and intervening in cases of CALSMO can result in suboptimal functional recovery, reduced quality of life,

and inefficient utilization of government healthcare resources.

Research on sarcopenia and obesity has focused predominantly on individuals aged 30 and older, as evidenced by existing studies [18-28]. Nevertheless, contemporary findings suggest that sarcopenia and obesity-related issues may arise as early as a person's twenties [29-36]. Identifying determinants is essential owing to the importance of instituting preventive measures against age-associated muscle loss at an earlier developmental stage. In particular, identifying morphological, clinical laboratory, and lifestyle determinants is a cost-effective and convenient approach for assessing sarcopenia. These proposed determinants offer accessible metrics that healthcare professionals can readily incorporate into routine screenings and assessments [37,38].

Morphological parameters, including height, weight, body mass index, and waist circumference, provide valuable insights into the physical aspects associated with sarcopenia. Clinical laboratory tests, such as blood markers and blood pressure, provide additional diagnostic indicators at a relatively lower cost than more advanced imaging techniques [39,40]. Lifestyle risk factors, such as tobacco and alcohol consumption, provide valuable information for an overall assessment [41,42]. Dual-energy X-ray absorptiometry is considered the gold standard for evaluating muscle mass and adipose tissue mass. Nevertheless, its high cost and concerns about radiation exposure make it less practical for widespread screening [43,44]. Utilizing a combination of morphological, clinical laboratory, and lifestyle factors is cost-effective and aligns with the principles of patient-centered care, ensuring a more holistic and accessible approach to sarcopenia assessments.

This study investigated the distribution dynamics and potential proposed determinants related to CALSMO within a community-dwelling young male demographic in Korea, particularly individuals aged between 20 and 29 years. The study focused on two main aspects: determining the specific distribution dynamics of CALSMO in this population and identifying proposed determinants associated with CALSMO in young men.

Ⅱ. Methods

1. Study Population

The data on the research population were derived from the Korean National Health and Nutrition Examination Surveys conducted by the Korean Center for Disease Control and Prevention. A comprehensive survey of 37,753 individuals was conducted from 2008 to 2011 using a complex sampling analysis known as stratified, clustered, multistage probability sampling. Of these, 36,306 individuals were excluded from the study because they did not fall within the age range of 20 to 29 years for men. Consequently, the remaining sample size comprised 1,447 participants. An additional 492 participants were excluded because they had neither undergone a dual-energy X-ray absorptiometry examination nor completed the health survey. Another 301 participants were excluded, neither a pure individual with age-related skeletal muscle loss nor pure obesity. Within this ultimate group, a set of 666 men aged between 20 and 29 years old was chosen for final analysis. These participants were categorized into two groups based on their skeletal muscle mass index score and obesity. The CALSMO group comprised 12 individuals, while the remaining 654 individuals were classified as the normal group. Ethical approval for the study was obtained from the institutional review board of the Center for Disease Control and Prevention, and all participants provided informed written consent before participating in the study.

2. Definition for Age-Related Skeletal Muscle Mass Loss

The age-related skeletal muscle mass loss was assessed

by measuring the appendicular skeletal muscle mass using dual X-ray absorptiometry (DEXA, QDR4500A Hologic, Inc., Bedford, MA, USA). The skeletal muscle mass index (SMI) was calculated by dividing the appendicular skeletal muscle mass (ASM) measured by DEXA by the body mass index (BMI), expressed in kilograms per square meter (kg/m^2). The criteria for diagnosing age-related skeletal muscle mass loss, as established by the Foundation for the National Institutes of Health Age-related Loss of Skeletal Muscle Mass Project, define this condition in men with an SMI < .789 [45]. This criterion was applied in diagnosing age-related skeletal muscle mass loss within the study population.

3. Definition of Obesity

Obesity is characterized by abnormal or excessive accumulation of body fat, with detrimental effects on overall health. It is identified based on a BMI $\geq$ 25 kg/m^2 and central obesity, denoted by a waist circumference (WC) exceeding 90 cm among the Asian population [23].

4. Variables

1) Morphological Measurement Variables

Standardized procedures were used for morphological measurements. The participants were instructed to remove their shoes, socks, hats, and hairpins and wear lightweight clothing. The height and weight were measured using precise automated body measurement equipment, with recorded values rounded to the nearest tenth of a centimeter or kilogram. The BMI was then calculated by dividing the weight by the square of the height. The waist circumference (WC) was measured to the nearest tenth of a centimeter in a horizontal plane at the midpoint between the last rib and the iliac crest at the end of a normal exhale.

2) Clinical Laboratory Test Variables

A trained practitioner measured the systolic blood pressure (SBP) and diastolic blood pressure (DBP) using a mercury sphygmomanometer. The blood pressure cuff was positioned at the heart level with the participants seated, following a minimum resting period of five minutes. The fasting glucose (FG), triglyceride, and total cholesterol (TC) levels were analyzed using the LABOSPECT 008AS platform developed by Hitachi High-Tech Co. in Tokyo, Japan. Blood samples were collected from the non-dominant arm after an overnight fast of at least eight hours. The collected blood was mixed immediately with a coagulation promoter, followed by centrifugation within a mobile examination vehicle. All tests were conducted within 24 hours of sample collection to ensure accurate analysis.

3) Lifestyle Factor

This study considered alcohol and tobacco consumption as lifestyle factors. Data on alcohol consumption and tobacco use were obtained through a survey, with categorization into three groups: non-users, former users, or current users. These measurements and variables are crucial for evaluating various health aspects and assessing potential risks associated with different diseases within the study population.

5. Data Analysis

The data in this investigation are presented as mean and standard deviation, examining the central tendencies and variations for each variable. Statistical analysis was conducted using SPSS 22.0, developed by IBM Corporation, headquartered in Armonk, NY, USA.

The individual adjusted weights were integrated into the study to ensure the representativeness of the entire Korean population. Each participant was assigned an individual sampling weight through a meticulous three-step process: calculation of the base weight, adjustments to accommodate non-responses, and post-stratification adjustments aligning with the population distribution from

the most recent census. Complex sampling analysis was used for all data assessments, considering the impact of these weight values. Differences between the CALSMO and normal groups were assessed using independent t-tests for parametric variables and chi-square tests for non-parametric variables. Multiple logistic regression analyses were also conducted, incorporating adjustments for covariates. This analytical approach aimed to predict the presence of CALSMO and ascertain the odds ratio of the proposed determinants associated with CALSMO, focusing on males. The predetermined alpha level of .05 served as the significance threshold for all variables in this study.

Ⅲ. Results

1. Distribution Dynamics of CALSMO

The calculated distribution dynamics of CALSMO, incorporating adjusted weighted values, was determined to be 1.81%, with a 95% confidence interval spanning from 1.02% to 3.18% (Table 1). In contrast, when assessing the unweighted distribution dynamics, CALSMO was identified in 1.80% of cases, with the remaining 98.20% representing participants in the normal group.

Table 1. Distribution dynamics of CALSMO

	CALSMO (N = 12)	Normal (N = 654)	Total (N = 666)
Un-weighted (%)	1.80	98.20	100
Weighted (%)	1.81 (1.02-3.18)	98.19 (96.82-98.98)	100

Weighed values present the 95% confidence interval.
CALSMO, coexistence of age-related loss of skeletal muscle mass and obesity.

2. Proposed Determinants

1) Morphological Measurement Variables

In this current study, the proposed determinants within the human dimension encompassed height, weight, BMI, and waist circumference. In particular, the skeletal muscle mass index was significantly different in the two groups, reaching a significance level of $p < .01$, as outlined in Table 2.

2) Clinical Laboratory Test

The investigation revealed statistically significant differences between the two groups concerning fasting glucose, triglyceride, and total cholesterol, all with p-values $< .01$. The SBP and DBP were not significantly different ($p > .05$). The data are listed in Table 3.

Table 2. Age, Morphological measurement

	CALSMO (N = 12)	Normal (N = 654)	p
Age (years)	26.5 ± 2.316	24.907 ± 2.661	.040
Height (cm)	168.45 ± 4.827	174.64 ± 5.436	.000
Weight (kg)	89.217 ± 8.662	66.574 ± 7.315	.000
BMI (kg/m^2)	31.425 ± 2.62	21.812 ± 2.023	.000
WC (cm)	99.842 ± 6.047	76.609 ± 5.859	.000
SMI (kg/m^2)	737.74 ± 42.231	1060.439 ± 111.477	.000

Values are expressed as the mean ± standard deviation. The independent t-test was exploited.
CALSMO, Coexistence of age-related loss of skeletal muscle mass and obesity; BMI, body mass index; WC, waist circumference; SMI, skeletal muscle mass index

Table 3. Clinical laboratory test

	CALSMO (N = 12)	Normal (N = 654)	p
FG (mg/dL)	97.667 ± 15.57	87.616 ± 9.933	.001
Triglyceride (mg/dL)	213.417 ± 180.664	107.375 ± 116.163	.002
TC (mg/dL)	200.583 ± 41.651	167.553 ± 29.178	.000
SBP (mmHg)	115.5 ± 15.306	113.08 ± 10.467	.432
DBP (mmHg)	79.917 ± 14.557	75.083 ± 9.412	.082

Values are expressed as the mean ± standard deviation. The independent t-test was exploited.
CALSMO, Coexistence of age-related loss of skeletal muscle mass and obesity; FG, fasting glucose; TC, total cholesterol; SBP, systolic blood pressure; DBP, diastolic blood pressure.

Table 4. Lifestyle factor

	CALSMO (N = 12)	Normal (N = 654)	p
Alcohol consumption (%) (current-/ex-/non-)	76.966 / 18.265 / 4.769	93.862 / 3.343 / 2.795	.004
Tobacco use (%) (current-/ex-/non-)	57.437 / 7.986 / 34.578	77.838 / 5.92 / 16.242	.305

Chi-square test was used to compare the two groups.
CALSMO, Coexistence of age-related loss of skeletal muscle mass and obesity.

3) Lifestyle Factor

There is a significant difference between the two groups in alcohol consumption with p-values < .01. Tobacco use was similar in the two groups, as indicated by p-values exceeding .05 (Table 4).

3. Multiple Logistic Regression for Odds Ratio

Table 5 lists the odds ratios and their corresponding 95% confidence intervals (CIs) for CALSMO in men, which were derived from multiple logistic regression analyses. Significant differences in the following variables were identified between the two groups: height, weight, BMI, waist circumference, skeletal muscle index, fasting glucose, triglyceride, and total cholesterol ($p < .05$). The respective values were .005(.004–006), 3.398(2.629–4.064), 1.756(1.534–1.946), 1.213(1.095–1.342), .001(.000–.001), 1.553(1.254–1.851), 1.102(1.081–1.124), and 1.043 (1.023–1.064).

Table 5. Multiple logistic regression for odds ratios of CALSMO

Variables	Odd ratios (95% of CI)	p
Height	.005(.004-.006)	.000
Weight	3.398(2.629-4.064)	.000
BMI	1.756(1.534-1.946)	.000
WC	1.213(1.095-1.342)	.000
SMI	.001(.000-.001)	.000
FG	1.553(1.254-1.851)	.000
Triglyceride	1.102(1.081-1.124)	.000
TC	1.043(1.023-1.064)	.000

Odds ratio values are present as the 95% confidence interval (CI). Multiple logistic regression was exploited.
CALSMO, Coexistence of age-related loss of skeletal muscle mass and obesity; BMI, body mass index; WC, waist circumference; SMI, skeletal muscle mass index; FG, fasting glucose; TC, total cholesterol

Ⅳ. Discussion

This study examined the distribution dynamics of CALSMO and its proposed determinants among a young male population. Healthcare professionals, including physical therapists, occupational therapists, and primary care clinicians, face challenges in diagnosing CALSMO precisely because of the limited knowledge and diagnostic resources. This deficit may result in overlooked diagnoses, potentially leading to complications from the adverse effects of CALSMO. The research examined variables strategically chosen for convenience and accessibility, serving as valuable instruments for identifying potential CALSMO cases. The critical determinants for CALSMO encompassed height, weight, body mass index, waist circumference, skeletal muscle index, fasting glucose, triglyceride, total cholesterol, and alcohol consumption. Given the close association between the morphological measurements and the diagnostic criteria of CALSMO, they will not be discussed separately in the ensuing section.

The fasting glucose as a proposed determinant of CALSMO aligned with the consistent findings across various investigations [46-48]. Perna et al. examined 639 patients and reported elevated glycemic levels within the CALSMO group [47]. Similarly, Lu et al. examined 600 community-dwelling individuals and concluded that the CALSMO group exhibited elevated fasting blood glucose levels compared to the normal groups [46]. Du et al. [48] evaluated 631 individuals in East China and disclosed that those with CALSMO displayed significantly higher blood glucose levels than the general population.

This association may be elucidated by the vital role of the skeletal muscles in regulating the postprandial glucose levels. Following the absorption of food from the gastrointestinal tract, approximately 80% of the glucose uptake, depending on insulin, transpires within the muscles. This intricate process involves the transportation of glucose from the bloodstream to the muscles, facilitated through insulin-dependent and insulin-independent mechanisms. Physical exercise triggers insulin release, prompting the translocation of glucose to the cell membrane and facilitating its entry into the muscles. Glucose uptake is governed by glucose transporters, regulated by the intracellular glucose metabolism. Impairments in skeletal muscle glucose uptake after meals are linked to a disrupted carbohydrate metabolism, resulting in a high blood glucose level [49].

The heightened triglyceride levels on CALSMO, as observed as a proposed determinant in this study, align with consistent findings from previous research on CALSMO [50,46,48]. Lu et al. [46] assessed community-dwelling elderly individuals and reported significant differences in triglyceride levels between the CALSMO and normal groups. Another study in China focusing on CALSMO revealed significantly elevated triglyceride levels within the CALSMO group compared to the normal elderly population [48]. Similarly, a longitudinal study conducted in Korea [28] reported that males with CALSMO had higher triglyceride levels than those in the normal group [50].

The contribution of total cholesterol as another proposed determinant in CALSMO in this study corresponded to previous findings [50-52]. Lim et al. [50] examined 287 Korean men and reported that men with CALSMO had higher TC levels than the normal group. Similarly, Habib [51] analyzed Saudi men with CALSMO and concluded that they had higher TC levels than the normal population. A study conducted at Ningxia Medical University in China revealed higher TC levels in men with CALSMO than those without [52].

The intricate relationship between elevated triglyceride levels and increased total cholesterol values may be due to the complex interplay of physiological factors. A crucial contributor to this phenomenon is insulin resistance [53]. In instances of insulin resistance, the body's cells exhibit an ineffective response to insulin, disrupting glucose metabolism. This disruption initiates a series of metabolic changes, including the overproduction of triglycerides in

the liver, contributing to the observed elevation in triglyceride levels. Another factor is inflammation, particularly elevated levels of inflammatory cytokines [53]. Inflammatory cytokines are vital signaling molecules in the body's immune response that can trigger a cascade of events influencing the lipid metabolism. Inflammation may induce the release of triglycerides from adipose tissue into the bloodstream, further contributing to elevated triglyceride levels. In addition, they can alter the composition and function of lipoproteins, resulting in changes in the total and LDL cholesterol levels [54].

Alcohol consumption has been identified as a determinant of CALSMO, corroborating previous studies [55,56]. Pang et al. examined more than 500 adults in the Singaporean community, establishing a robust connection between alcohol consumption and age-related skeletal muscle mass decline [56]. Similarly, Daskalopoulou et al., in a multicenter population-based study involving 8694 individuals, reported that alcohol consumption is a risk factor for CALSMO [55]. The underlying mechanism linking alcohol consumption to ALSMM is delineated as follows: alcohol has an adverse effect on protein synthesis, a crucial process for the body in muscle building. This impact can lead to a gradual decline in muscle mass and strength over time [57]. Moreover, alcohol can impede the body's ability to absorb essential nutrients, such as proteins and amino acids, for muscle growth and repair. Furthermore, alcohol consumption may induce dehydration, further impeding muscle function and recovery [58]. The interplay of alcohol and low muscle mass triggering obesity is often observed in CALSMO. This condition involves the simultaneous reduced muscle mass and elevated body fat. Despite the excess body fat, individuals with CALSMO experience muscle loss, leading to reduced physical activity and a decline in metabolic rate. This combination contributes to the accumulation of body fat and the development of obesity [26].

The study offers pivotal insights into the distribution dynamics and specific determinants linked to CALSMO within the young male demographic of the community. The dataset in this investigation was comprehensive and reflective of the broader Korean populace. The study strategically used the widely acknowledged Dual-Energy X-ray Absorptiometry (DEXA) measurement technique to diagnose CALSMO precisely. Nevertheless, it is imperative to acknowledge a notable limitation within the study design. Although instrumental in capturing a snapshot of the population, utilizing a cross-sectional framework inherently falls short of establishing definitive causal relationships. Therefore, a prospective longitudinal approach will be needed to overcome this limitation and improve understanding. This longitudinal strategy, involving repeated measurements of the same individuals at distinct time intervals, has the potential to unravel causal connections more robustly, providing a more nuanced comprehension of the intricate dynamics of CALSMO.

Ⅴ. Conclusion

This study examined the distribution dynamics and pivotal proposed determinants associated with CALSMO among South Korean males in their twenties. The calculated distribution dynamics for CALSMO in this demographic was 1.81%. The determinants in the morphological measurements include height, weight, body mass index, waist circumference, and skeletal muscle mass. In the clinical laboratory test, fasting glucose, triglyceride levels, total cholesterol, and alcohol consumption emerged as crucial determinants. Nevertheless, a longitudinal study design with repeated measurements on the same participants over an extended period will be needed to augment the credibility of these findings. Such an approach can potentially unravel causal relationships among the variables scrutinized in this study, thereby advancing the comprehension of CALSMO among young men.

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