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Research Article

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Coexistence of Age-related Loss of Skeletal Muscle Mass and Obesity in Korean Men in Their Thirties: Understanding Incidence Rate and Key Influencing Elements

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| Abstract |

PURPOSE: The coexistence of age-related skeletal muscle mass loss and obesity poses a substantial health risk for individuals because it combines the detrimental effects of muscle mass reduction associated with aging and the health complications from obesity. This study aimed to identify the incidence rate and key influencing elements among Korean men in their thirties.

METHODS: A cross-sectional study involving 934 male participants was performed using complex sampling analysis. Various influencing elements were investigated, including age, height, weight, body mass index, waist circumference, skeletal muscle mass index, smoking and drinking behaviors, systolic and diastolic blood pressure, fasting glucose levels, triglyceride, and cholesterol levels.

RESULTS: The incidence rate was 2.90%. The key influencing elements were age, height, weight, body mass index, waist circumference, skeletal muscle index, systolic blood pressure, fasting glucose, triglyceride, and total cholesterol ($p < .05$).

CONCLUSION: This study identified the incidence rate and key influencing element for CALSMO among Korean younger community-dwelling men.

Key Words: Age-related skeletal muscle mass loss, Incidence rate, Influencing elements, Obesity

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Ⅰ. Introduction

The coexistence of age-related skeletal muscle mass loss and obesity, abbreviated as CALSMO, represents a medical condition wherein an individual concurrently experiences the dual challenges of age-related decline in skeletal muscle mass and obesity, which is characterized by the excessive accumulation of adipose tissue, leading to adverse health consequences. CALSMO poses a significant health risk for individuals because it combines the detrimental effects of muscle mass reduction associated with aging and the health complications from obesity [1,2].

The elderly population in Asia is rapidly expanding, and South Korea stands out as one of the countries in the region with a significantly high proportion of older adults. In 2050, South Korea's elderly population will experience a substantial increase from the current 15% (as of 2022) to a remarkable 40%, with the number of older individuals surging from five million to nineteen million [3]. This demographic shift raises concerns regarding potential future health challenges associated with aging, including age-related loss of skeletal muscle mass and obesity in Korean society. Furthermore, the obesity rates increased significantly in South Korea from 2009 to 2019 [4]. This growing incidence rate of obesity among the elderly, combined with the expanding elderly population, highlights the increasing key influencing element for the CALSMO in South Korean society. Therefore, it is essential to prioritize proactive measures to prevent CALSMO within the context of Korean society.

The simultaneous presence of obesity and low skeletal muscle mass can exert detrimental effects on health, aggravate chronic degenerative ailments, increase disability, and prolong hospitalization periods. Consequently, this dual condition poses a formidable challenge to the sustainability and efficacy of healthcare systems across primary and secondary care, social support structures, public health initiatives, and policymaking efforts [5]. Several studies have provided compelling evidence that individuals afflicted with this condition experience more severe instances of illness, greater levels of disability, and higher mortality rates than those dealing with either low muscle mass or obesity in isolation [6,7]. In addition, obesity hampers the development and retention of muscle mass, making it a challenge to diagnose and recognize its clinical implications [8].

Furthermore, the age-related loss of skeletal muscle mass is higher in males than females [9,10]. Bouchard et al. [11] conducted a study involving 904 Canadians. They reported that the incidence of CALSMO was 19% and 11% in men and women, respectively. In a separate study as part of the Framingham study in the United States, Defour et al. [10] examined 767 individuals. They discovered that the CALSMO incidence rate was 8% among men and 4% among women. This indicates that men are more susceptible to CALSMO as they age than women. The challenges associated with identifying key influencing elements and managing CALSMO among older adults persist, with a particular focus on the significant proportion of affected males. These challenges become apparent when comparing the existing research on CALSMO in males with the more extensively studied CALSMO in females [12-14].

Despite the profound implications associated with CALSMO, healthcare professionals and primary care clinicians often encounter challenges because they lack the necessary diagnostic tools and knowledge for its detection [15-20]. In a typical primary care scenario, where general practitioners allocate less than ten minutes per patient visit, the initial step involves recognizing the potential likelihood of CALSMO in a patient before considering a referral for diagnosis and treatment. Moreover, the limited understanding of CALSMO as a distinct medical condition among clinicians increases the probability of overlooking the diagnosis [21]. Therefore, it is vital to understand the key influencing elements crucial for early detection and prevention. The early diagnosis of CALSMO is of utmost importance for identifying symptomatic patients at the earliest possible stage [22]. Any delay or failure to diagnose and intervene in cases of CALSMO can lead to poor functional recovery, diminished quality of life, and inefficient utilization of government healthcare resources.

This study examined the incidence rate and potential key influencing element associated with CALSMO among the Korean community-dwelling younger male population, specifically those aged between 30 and 39 years. This research evaluated two primary areas: a distinct incidence rate of CALSMO within this population and the key influencing element that may be associated with CALSMO in younger-aged men.

Ⅱ. Methods

1. Subjects and Data Sampling

This study relied on data from the Korean National Health and Nutrition Examination Surveys conducted by the Korean Center for Disease Control and Prevention. The data collection process used a sophisticated sampling method called stratified, clustered, multistage probability sampling. A comprehensive survey was conducted with a substantial participation of 37,753 individuals from 2008 to 2011. On the other hand, 35,355 were excluded from the study because they did not fall within the specified age range of 30 to 39 years old men. Consequently, the final sample size for the study was composed of 2,398 participants. An additional 1,464 participants were excluded from the study because they had neither undergone a dual-energy X-ray absorptiometry examination nor completed the health survey. Within this final group, a subset of 934 men aged between 30 and 39 years old was selected for the analysis. These participants were then categorized into two groups based on their skeletal muscle mass index score. The CALSMO group included 25 individuals; the remaining 909 individuals were classified as the normal group. The study received ethical approval from the institutional review board of the Center for Disease Control and Prevention, and all participants provided informed written consent to participate in the study.

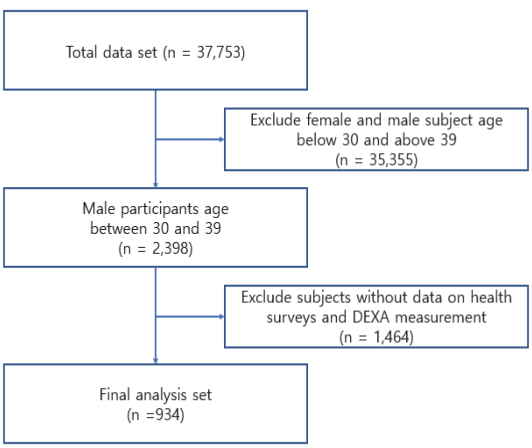

Fig. 1. Flowchart for participants selection.

2. CALSMO Criteria

The two components of CALSMO, which involve the coexistence of age-related loss of skeletal muscle mass and obesity, are defined as follows. The age-related loss of skeletal muscle mass 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) by DEXA by the body mass index (BMI), expressed in kilograms per square meter (kg/m^2). The Foundation for the National Institutes of Health Age-related Loss of Skeletal Muscle Mass Project established the criteria for diagnosing age-related loss of skeletal muscle mass. In men, age-related loss of skeletal muscle mass is defined as having an SMI of less than .789. This methodology was used to diagnose age-related loss of skeletal muscle mass within the study population. Obesity is characterized by the abnormal or excessive accumulation of body fat, which can have detrimental effects on overall health. It is identified based on a BMI $\geq$ 25 kg/m^2 and central obesity, which is characterized by a waist circumference (WC) exceeding 90 cm among the Asian population [23].

3. Research Variables

The study variables were age, height (measured in centimeters), weight (measured in kilograms), BMI, waist circumference (WC), skeletal muscle index (SMI), smoking and drinking habits, fasting glucose levels, triglyceride levels, total cholesterol (TC) levels, systolic and diastolic blood pressure. The BMI was calculated using height and weight data. The waist circumference was determined by measuring the circumference at the midpoint between the bottom of the ribcage and the top of the iliac crest during full expiration. The Skeletal Muscle Index (SMI) is an indicator of muscle mass, measuring to determine CALSMO. The participants' smoking and drinking status was categorized into three groups: non-users, ex-users, or current users. The fasting glucose level assesses the blood glucose levels following an eight-hour fasting period, a parameter for evaluating glycemic control. Triglycerides is a measurement of the blood triglyceride levels, a component of the lipid profile. The total cholesterol (TC) is an evaluation of total cholesterol levels in the blood, another significant lipid marker. The systolic blood pressure (SBP) and diastolic blood pressure (DBP) are the higher and lower of the two blood pressure readings, respectively, measured using a mercury sphygmomanometer after a ten-minute rest. These variables were chosen to investigate the key influencing elements associated with CALSMO and to explore potential connections. Each variable provided unique insights into the diverse aspects of participants' health, enabling a comprehensive examination of the research objectives.

4. Data Analysis

The study data presents the mean and standard deviation as statistical metrics to convey the measurement characteristics. The statistical analysis adopted a complex sampling analysis, considering the nationwide representation by integrating the individual weights offered by the Korean National Health and Nutrition Examination Survey. The analysis was conducted using the SPSS 22.0 window version, a product of IBM Corporation based in Armonk, NY, USA.

The data in this study adhered to a meticulously designed stratified, clustered, multistage probability sampling framework. The key influencing elements for CALSMO were assessed using independent t-tests and chi-square analyses. Multiple logistic regression analysis was performed to determine the odds ratio of CALSMO. The statistical significance level was set to $p = .05$.

Table 1. Incidence rate of CALSMO

	CALSMO (n = 25)	Normal (n = 909)	Total (N = 934)
Un-weighted (%)	2.68	97.32	100
Weighted (%)	2.9 (1.92-4.36)	97.10 (95.64-98.08)	100

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

Ⅲ. Results

1. CALSMO Incidence Rate

The Incidence rate of CALSMO, accounting for the weighted values, was determined to be 2.90% (with a 95% confidence interval of 1.92–4.36). On the other hand, when examining the unweighted incidence rate, CALSMO was found in 2.68% of cases, while the normal group contained 97.32% of participants (Table 1).

2. Influencing Elements of CALSMO

The clinical influencing elements, such as age, height, weight, BMI, WC, SMI, SBP, fasting glucose, triglyceride, and TC, exhibited statistical significance ($p < .05$), as listed in Table 2. In contrast, the DBP, drinking status, and smoking status were not significant ($p > .05$).

3. Multiple Logistic Regression for Odds Ratio

Table 3 lists the odds ratios and their corresponding 95% confidence intervals (CIs) for CALSMO in men obtained from multiple logistic regression analyses. Significant differences in the following variables were observed between the two groups: age, height, weight, BMI, WC, SMI, SBP FG, triglyceride and TC ($p < .05$). The respective values were .000(.000–.000), 3.609 (2.461–4.459), 6.609 (5.855–7.459), 11.702 (8.194–16.711), .000 (.000–.000), .743 (.675–.818), 1.232 (1.165–1.302), 1.022 (1.015–1.029), 1.019 (1.001–1.038), .000 (.000–.000), 3.609 (2.461–4.459), 6.609 (5.855–7.459), 11.702 (8.194–

Table 2. Clinical key influencing element related to CALSMO

	CALSMO (n = 25)	Normal (n = 909)	p
Age (years)	35.32 ± 3.024	35.01 ± 2.77	.580
Height (cm)	166.18 ± 5.52	172.96 ± 5.452	.000
Weight (kg)	81.48 ± 12.28	66.35 ± 6.882	.000
BMI (kg/m^2)	29.38 ± 3.07	22.15 ± 1.85	.000
WC (cm)	97.09 ± 6.53	78.38 ± 5.89	.000
SMI (g/m^2)	741.48 ± 48.69	1011.31 ± 104.69	.000
FG (mg/dL)	102.33 ± 16.49	92.86 ± 19.24	.017
Triglyceride (mg/dL)	317.25 ± 323.69	134.93 ± 110.33	.000
TC (mg/dL)	206.50 ± 32.28	184.32 ± 33.23	.001
SBP (mmHg)	120.56 ± 13.10	114.27 ± 11.95	.010
DBP (mmHg)	81.32 ± 10.80	77.66 ± 10.16	.077
Drinking status (%) (current-/ex-/non-users)	100 / 0 / 0	93.745 / 3.9 / 2.355	501
Smoking status (%) (current-/ex-/non-users)	73.151 / 9.137 / 17.713	74.694 / 11.776 / 13.53	.865

CALSMO: Coexistence of age-related skeletal muscle mass loss and obesity; 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 3. Multiple logistic regression for odds ratios of CALSMO

Variables	Odd ratios (95% of CI)	p
Height	.000 (.000–.000)	.000
Weight	3.609 (2.461–4.459)	.000
BMI	6.609 (5.855–7.459)	.000
WC	11.702 (8.194–16.711)	.000
SMI	.000 (.000–.000)	.000
FG	1.232 (1.165–1.302)	.000
Triglyceride	1.022 (1.015–1.029)	.000
TC	1.019 (1.001–1.038)	.039
SBP	.743 (.675–.818)	.000

CALSMO: Coexistence of age-related skeletal muscle mass loss and obesity; BMI: body mass index; WC: waist circumference; SMI: skeletal muscle mass index; FG: fasting glucose; TC: total cholesterol; SBP: systolic blood pressure.

16.711), .000 (.000–.000), .743 (.675–.818), 1.232 (1.165–1.302), 1.022 (1.015–1.029), and 1.019 (1.001–1.038).

Ⅳ. Discussion

This investigation examined the incidence rate of CALSMO and its key influencing elements among younger men. Physical therapists and occupational therapists, as well as primary care clinicians, encounter challenges in accurately diagnosing CALSMO because of the limited knowledge and diagnostic tools. This dearth of resources can lead to missed diagnoses and potential complications stemming from the adverse effects of CALSMO. The research examined a set of variables to address this issue. These variables were chosen for convenience and ease of access, making them valuable tools for identifying potential

CALSMO patients. The key influencing elements for CALSMO are height, weight, BMI, WC, SMI, fasting glucose, triglyceride, TC, and SBP.

The fasting glucose levels were identified as a significant influencing element for CALSMO, which is consistent with findings from several prior studies [24-26]. For example, Perna et al. [25] examined 639 patients and reported higher levels of glycemia in the CALSMO group. Similarly, Lu et al. [24] investigated 600 community-dwelling individuals and concluded that the CALSMO group had higher fasting blood glucose levels than the normal groups. Du et al. [26] examined 631 individuals residing in East China. They reported that individuals with CALSMO exhibited significantly higher blood glucose levels than the general population. One potential underlying mechanism for this association revolves around the crucial role of the skeletal muscle in regulating the postprandial glucose levels. After food is absorbed from the gastrointestinal tract, approximately 80% of glucose uptake, which relies on insulin, occurs within the muscles. This process involves transporting glucose from the bloodstream to the muscle, facilitated using insulin-dependent and insulin-independent mechanisms. During physical exercise, insulin is released, prompting the translocation of glucose to the cell membrane, facilitating its entry into the muscle. The glucose uptake is governed by glucose transporters, which are regulated by the intracellular glucose metabolism. Impairments in skeletal muscle glucose uptake after meals are associated with a disrupted carbohydrate metabolism, ultimately leading to elevated blood glucose levels [27].

High triglyceride levels influence CALSMO, which is consistent with previous CALSMO research [28,24,26]. Lu et al. [24] evaluated community-dwelling elderly individuals and reported significant differences in triglyceride levels between the CALSMO and normal groups. A study on CALSMO in China showed that the CALSMO group exhibited significantly elevated triglyceride levels compared to the normal elderly population [26]. A longitudinal study conducted in Korea [28] also reported that male CALSMO individuals had higher triglyceride levels than those in the normal group.

The total cholesterol is another influencing factor [28-30]. Lim et al. [28] investigated 287 Korean men and showed that men with CALSMO have higher TC levels than the normal group. Habib [29] analyzed Saudi men with CALSMO and concluded that they have higher TC levels than the normal population. A Ninxia Medical University study in China reported that men with CALSMO showed increased TC levels [30]. The underlying reason for the elevated triglyceride levels and increased total cholesterol values may be a complex interplay of physiological factors. One crucial contributor to this phenomenon is insulin resistance [32. In cases of insulin resistance, the body's cells do not respond effectively to insulin, disrupting glucose metabolism. This disruption can trigger a cascade of metabolic changes, including the overproduction of triglycerides by the liver. Consequently, triglyceride levels in the bloodstream increase, contributing to the observed elevation. Another cause lies in inflammation, specifically higher levels of inflammatory cytokines [33]. Inflammatory cytokines are signaling molecules involved in the body's immune response. Elevated levels can set off a chain reaction that influences the lipid metabolism. Inflammation can promote the release of triglycerides from adipose tissue into the bloodstream, contributing further to the elevation in triglyceride levels. Moreover, it can alter the composition and function of lipoproteins, leading to changes in the total and LDL cholesterol levels [31].

The SBP was found to be an influencing element for CALSMO, concurring with previous research studies [24,32,33]. Similarly, a Taiwan community CALSMO dwelling study [24] reported higher SBP levels in the CALSMO group than in the normal group. A representative sample from a British male cohort study [32] also revealed a significant SBP increase in the CALSMO group compared to the normal group. Yin et al. [33] reported that males in the CALSMO group had higher SBP levels than males in the normal group. The observed increase in both systolic blood pressure has several plausible explanations. The first is the intricate relationship between muscle loss and metabolic changes, which can result in decreased energy expenditure and reduced physical activity. These factors can contribute to the development of insulin resistance and increased arterial stiffness [34-36]. Another contributing factor is the accumulation of visceral fat, which initiates an inflammatory response that thickens the blood vessel walls, hinders blood flow, and narrows vascular passages [37]. The reduced muscle mass and the build-up of adipose tissue in the visceral region may play a role in the hypertension observed in men with CALSMO.

Nevertheless, the DBP, alcohol consumption status, and smoking status were not influencing elements for CALSMO. A previous CALSMO study [38] with an elderly population reported that DBP is not an influencing factor for CALSMO. An age-related loss of skeletal muscle study [39,40] reported that drinking status and smoking status are not associated directly with skeletal muscle loss. The underlying reason is that habitual behaviors, such as alcohol consumption and smoking, may not be substantial enough to cause significant muscle loss. This suggests that age-related muscle loss is a complex process influenced by multiple factors, including physical inactivity, hormonal changes, inadequate nutrition, and genetic factors. Although excessive alcohol and tobacco use can have detrimental health effects, their direct impact on muscle loss may be less pronounced than other factors [41].

This study provides significant insights into the incidence rate and specific influencing elements associated with CALSMO among younger men in the community. The data used are representative of the Korean population. This study used the widely accepted DEXA measurement technique for CALSMO diagnosis. Nevertheless, this study had one limitation. The cross-sectional design used in this study cannot definitively establish causal relationships. Therefore, a longitudinal approach involving measuring the same individuals at multiple time points would be valuable for investigating causal relationships more effectively.

Ⅴ. Conclusion

The study presents findings regarding the incidence rate and clinical influencing element associated with CALSMO in Korean males in their 30s. The incidence rate of CALSMO among males was 2.9 (1.92–4.36) %. The key influencing elements for CALSMO in males included low height, high weight, elevated body mass index, increased waist circumference, reduced skeletal muscle index, increased fasting glucose, enhanced triglyceride, elevated total cholesterol, and higher levels of systolic and diastolic blood pressure.

The credibility of this research can be enhanced using a longitudinal study design involving repeated measurements of the same participants over time. Such an approach would help establish the causal relationships between the variables examined in this study, further advancing the understanding of CALSMO among younger men.

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