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Research Article

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Analyzing Proportion and Susceptibility Markers of Sarcopenia In Korean Younger Female

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| Abstract |

PURPOSE: This investigation in the study aimed to assess to determine proportion and susceptibility makers of sarcopenia in Korean younger female aged 30 to 39 years.

METHODS: To address the complex sampling design of Korea National Health and Nutrition Examination Surveys, appropriate individual weights were incorporated into the analysis. The data employed a stratified, clustered, multistage probability sampling design. A total of 2,098 participants were enrolled and categorized into two groups based on their skeletal muscle mass index scores. One hundred and twenty-four individuals were placed in the sarcopenia group, while 2,024 were allocated to a normal group. The study examined various markers as variables, including age, height, weight, body mass index waist circumference, skeletal muscle mass index, systolic and diastolic blood pressure, fasting glucose, triglyceride, and total cholesterol levels, and smoking and drinking habits.

RESULTS: The study found that proportion of sarcopenia in this population was 3.78% (CI: 2.89-4.94) in sarcopenia group and 96.22% (CI: 95.06-97.11) in normal with weighed values. Several susceptibilities including height, weight, BMI, waist circumference, diastolic blood pressure, and total cholesterol levels were risk factor for sarcopenia ($p < .05$), exhibited significant differences between the sarcopenia and normal groups.

CONCLUSION: This investigation provides the proportion of sarcopenia and identifies relevant susceptibility markers among community dwelling younger women in Korea.

Key Words: Odds ratio, Proportion, Sarcopenia, Susceptibility marker

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Ⅰ. Introduction

Advancements in applied science and healthcare technology, combined with socioeconomic development, have led to a worldwide increase in the average lifespan. In 2019, approximately more than seven hundreds million people globally were aged 65 years or older, and this number is projected to grow to 1.5 billion by 2050 [1]. Life expectancy has risen in all countries, with a disproportionately larger increase in the elderly population [2]. Consequently,

healthcare services are facing additional strain due to the growing number of elderly individuals. To cope with the challenges posed by age-related chronic diseases and the increasing burden on healthcare systems. It is essential to gain a deeper understanding of aged related condition.

Sarcopenia is one of most common age-related disease and a condition that develops gradually in aging individuals, characterized by the widespread and progressive loss of muscle mass and function [3]. This age-related decline in muscle health is closely linked to frailty, a state in which elderly individuals become more vulnerable to various stressors that can lead to adverse health outcomes, increased risk of disability, and even mortality [4]. Frailty is essentially a state of heightened susceptibility in the elderly population.

Understanding and addressing both sarcopenia and frailty are crucial in promoting healthy aging and improving the overall well-being of older adults. These conditions can put significant strain on healthcare systems and impact the quality of life of elderly individuals. By developing interventions that target sarcopenia and frailty, we can potentially reduce the burden on healthcare services and enhance the health outcomes and longevity of the aging population.

Several studies have consistently shown that the proportion of sarcopenia is greater in females compared to males. For instance, Dam et al. conducted a screening of 10,063 individuals and reported a prevalence of 11.80% in women and 5.10% in men [5,6]. Similarly, Hunt et al. investigated 1,921 Japanese individuals residing in the community and found a proportion of sarcopenia of 16.56% in females and 10.34% in males [6].

A substantial portion of the older adult population, particularly females in Korea, faces a considerable risk of developing sarcopenia. However, the early detection of sarcopenia in female patients remains a complex task in comparison to the extensive research focused on male sarcopenia patient [7-10]. The rising number of elderly females and the potential adverse consequences associated with sarcopenia underscore the importance of addressing this issue. Yet, healthcare professionals, including physical therapists and primary care clinicians, encounter challenges in diagnosing sarcopenia due to limited knowledge and access to appropriate diagnostic tools. In primary care settings, where time with each patient is constrained, clinicians must assess the likelihood of sarcopenia before considering referrals for diagnosis and treatment. Moreover, the lack of awareness about sarcopenia as a medical condition among clinicians increases the risk of missed diagnoses [11]. To overcome these challenges effectively, it is crucial to comprehend the key susceptibility markers associated with early detection and prevention [12]. Timely identification of symptomatic individuals can significantly impact early diagnosis and intervention, as delays or missed diagnoses can lead to complications such as compromised functional recovery, diminished quality of life, and inefficient utilization of healthcare resources.

However, it is noteworthy that the majority of sarcopenia research has primarily concentrated on individuals aged 40 years and older [13-21], despite the fact that age-related muscle loss can initiate as early as the 30s [22-30]. Hence, the identification of susceptibility markers for muscle loss at an earlier stage becomes imperative for effective prevention and treatment of this condition. Thus, the aim of present study investigates the susceptibility markers and proportion of sarcopenia in younger women between 30 and 39 years old. The hypothesis posited that specific proportion and susceptibility markers might be exist in this particular age group.

Ⅱ. Methods

1. Research Participants

The present study relied on data obtained from the Korea National Health and Nutrition Examination Surveys (KNHNES), which is a survey program established by the

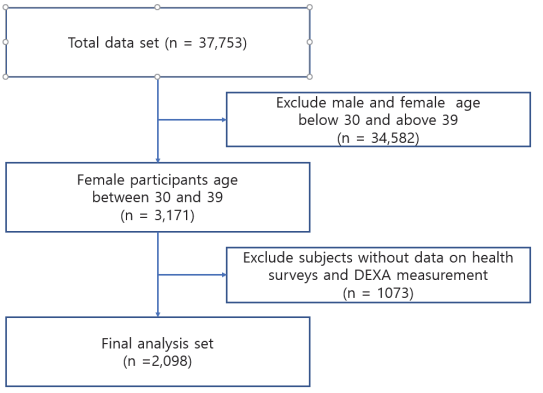

Fig. 1. Flow chart for subject selection.

Centers for Disease Control and Prevention to monitor health-risk behaviors in the population. The survey employed a stratified, clustered, multistage probability sampling design and involved the participation of 37,753 individuals during the period from 2008 to 2011. After excluding 34,582 individuals who fell below 30 or above 39 years of age, the final dataset consisted of 3,171 participants. Among them, 1,073 subjects were further excluded due to the unavailability of data on their health surveys and dual X-ray absorptiometry. Ultimately, the final analysis included 2,098 women aged between 30 and 39 years old. Based on their skeletal muscle mass index score, the participants were divided into two groups, with 74 individuals assigned to the sarcopenia group and 2,024 individuals to the normal group (Fig. 1).

2. Research Variables

The research encompassed several variables for the analysis, including age, height, weight, body mass index (BMI), waist circumference (WC), skeletal muscle index (SMI), smoking and drinking habits, fasting glucose levels, triglyceride levels, total cholesterol (TC) levels, systolic blood pressure, and diastolic blood pressure.

To determine the waist circumference, the researchers measured the circumference at the midpoint between the bottom of the ribcage and the top of the iliac crest during full expiration. For blood tests, participants underwent an eight-hour fast, and systolic and diastolic blood pressures were measured using a mercury sphygmomanometer after a ten-minute rest in a chair. Smoking and drinking statuses were categorized into non-users, ex-users, and current users.

3. Criteria for Sarcopenia

The criteria for diagnosing sarcopenia involve the measurement of skeletal muscle mass in the limbs. This condition is identified using the ICD-10-CM code M62.84. To determine the amount of skeletal muscle mass in the limbs [31], the researchers utilized Dual X-ray absorptiometry with QDR4500A equipment from Hologic, Inc. in Bedford, MA.

The assessment of muscle mass was conducted by calculating the ASM (Appendicular Skeletal Muscle Mass) to BMI ratio, commonly referred to as the skeletal muscle mass index (SMI). The SMI value was compared to specific thresholds to diagnose sarcopenia: a SMI value below than .521 for women, in accordance with the criteria established by the Foundation for the National Institutes of Health sarcopenia Project [25]. This rigorous methodology accurately identified sarcopenia among the participants in the study.

4. Analysis

Statistical analyses for this study were performed using SPSS version 22.0. To address the complex sampling design of KNHANES, appropriate weights were incorporated into the analysis. The data employed a stratified, clustered, multistage probability sampling design. To compare the variables between participants with sarcopenia and those without, independent t-tests and chi-square analyses were employed. These tests allowed for the assessment of any significant differences in the variables based on sarcopenia. Furthermore, multiple logistic regression analysis with enter method was conducted to determine the odds ratio of sarcopenia. This analysis helps identify the relationship between sarcopenia and the various markers under

investigation. Throughout the study, the statistical significance level was set at p = .05, ensuring that only results with a probability of less than 5% of occurring by chance were considered significant. This approach helps ensure the robustness and reliability of the findings.

Ⅲ. Result

1. Proportion of sarcopenia

In Table 1, the weighted proportion of sarcopenia was reported as 3.78% (with a 95% confidence interval of 2.89-4.94%). This value was calculated using the specific weights to individuals account for the complex sampling design of the study. On the other hand, the unweighted proportion of sarcopenia, which does not consider the sampling design, was found to be 3.53%. These proportion figures provide valuable insights into the occurrence of sarcopenia in the studied population, considering both the weighted and unweighted estimates.

Table 1. Proportion of sarcopenia

	Sarcopenia (n = 74)	Normal (n = 2024)	Total (N = 2098)
Un-weighted (%)	3.53	96.47	100
Weighted (%)	3.78 (2.89-4.94)	96.22 (95.06-97.11)	100

Weighed values present the 95% confidence interval.

2, Susceptibility Markers for Sarcopenia

The statistical analysis revealed that Susceptibility markers including height, weight, BMI, WC, SMI, DBP, and total cholesterol, showed significant differences between two group ($p < .05$). On the other hand, other variables such as SBP, drinking status, smoking status, fasting glucose, and triglyceride levels did not demonstrate significant differences ($p > .05$). These findings are presented in Table 2 and provide significant level, mean,

Table 2. Susceptibility markers related to sarcopenia

	Sarcopenia (N = 74)	Normal (N = 2024)	p
Age (years)	35.405 ± 2.689	34.895 ± 2.781	.121
Height (cm)	151.807 ± 4.99	160.073 ± 5.088	.000
Weight (kg)	59.488 ± 11.706	57.016 ± 9.2	.025
BMI (kg/m^2)	25.785 ± 4.745	22.239 ± 3.343	.000
WC (cm)	79.547 ± 11.282	74.704 ± 8.863	.000
SMI (g/m^2)	498.797 ± 19.088	673.382 ± 77.827	.000
SBP (mmHg)	107.851 ± 11.276	105.93 ± 11.43	.155
DBP (mmHg)	73.068 ± 9.053	70.309 ± 8.974	.009
Drinking status (%) (current-/ex-/non-drinker)	75.432 / 21.521 / 3.047	78.309 / 16.229 / 5.463	.360
Smoking status (%) (current-/ex-/non-smoker)	9.068 / 7.278 / 83.654	13.12 / 5.054 / 81.826	.594
FG (mg/dL)	93.366 ± 13.142	90.65 ± 14.596	.122
Triglyceride (mg/dL)	104.155 ± 50.776	90.584 ± 62.726	.072
TC (mg/dL)	189.07 ± 36.312	174.785 ± 30.288	.000

WC, waist circumference; SMI, skeletal muscle mass index SBP, systolic blood pressure; DBP, diastolic blood pressure; FG, fasting glucose; TC, total cholesterol.

Values are expressed as the mean ± standard deviation. The independent *t*-test and chi-square test were performed.

Table 3. Odds ratio for sarcopenia

Variables	Odds ratio (95% CI)	p
Height	.005(.003–.007)	.000
Weight	67.327(20.981-216.046)	.000
BMI	10.693(.070–167.786)	.000
WC	3.716(2.207-6.257)	.000
SMI	.002(.001–.003)	.000
TC	1.108(1.062-1.157)	.000
DBP	10.459(7.723-14.164)	.000

WC, waist circumference; SMI, skeletal muscle mass index; TC, Total cholesterol; DBP, diastolic blood pressure.
Odds ratio values are present as the 95% confidence interval (CI). Multiple logistic regression with enter method in complex sampling performed.

and standard deviation about the markers that have a significant impact on the sarcopenia in the population.

3. Multiple Logistic Regression for Odds Ratio

Table 3 lists the odds ratios with their corresponding 95% confidence intervals (CI) are presented for significant predictors of sarcopenia in females, as determined through multiple logistic regression analysis. The following variables were found to be statistically significant ($p < .05$): height .005(.003–.007), weight 67.327(20.981-216.046), BMI 10.693(.070–167.786), WC 3.716(2.207-6.257), SMI .002 (.001–.003), TC 1.108(1.062-1.157), DBP 10.459(7.723-14.164).

Ⅳ. Discussion

The purpose of this study was to examine the proportion and susceptibility markers of sarcopenia in individuals living in the community. Given the increasing aging population in Korea and Asia, the incidence of sarcopenia has been on the rise, particularly among females. However, healthcare professionals, including physical and occupational therapists, often encounter challenges in diagnosing sarcopenia due to limited knowledge and diagnostic tools, resulting in missed diagnoses and potential complications. To address this issue, the study carefully considered easily accessible and cost-effective variables, such as height, weight, body mass index, waist circumference, skeletal muscle index, blood pressure, blood laboratory test variables, and drinking and smoking status.

The significance of early detection and prevention of sarcopenia cannot be overstated, considering its potential negative consequences. By identifying several susceptibility markers associated with sarcopenia in this population, including circumference measurements, systolic and diastolic blood pressure, fasting glucose, triglyceride, and total cholesterol levels, the study provides valuable insights for healthcare professionals to intervene proactively and implement effective preventive strategies against sarcopenia.

Sarcopenia has consistently been associated with certain susceptibility markers, specifically waist circumference. Various studies have consistently reported that women with larger waist circumferences are at a higher risk of developing sarcopenia [32-34]. For instance, a population-based cohort study conducted in the US National Health and Nutrition Survey revealed that adults with sarcopenia exhibited a larger waist circumference [33]. Similarly, a cohort study conducted among individuals with sarcopenia in Brazil also observed a larger waist circumference compared to the normal population [34]. Additionally, a study carried out in Japan among community-dwelling individuals suggested that those with sarcopenia tended to have larger waist circumferences than non-sarcopenic individuals [32]. The underlying theoretical rationale behind the association between larger waist circumference and sarcopenia lies in the interdependence of enhanced fat mass and reduced muscle mass [35]. Sarcopenic individuals often face issues with muscle power and function due to muscle loss, leading to reduced physical activity levels, such as difficulties in sitting-to-stand and

walking long distances indoors and outdoors [36]. Consequently, this reduced physical activity is strongly linked to decreased total daily energy expenditure and increased fat stores, particularly in the visceral and abdominal areas, resulting in an enlargement of the waist volume [36]. As a result, the relationship between decreased muscle mass and increased fat mass in sarcopenia is bidirectional and mutually reinforcing [37].

Total cholesterol levels were identified as a susceptibility marker for sarcopenia in women. This finding is consistent with earlier studies on sarcopenia [32,38]. For instance, Du et al. [38] reported that the female sarcopenic group had higher total cholesterol levels compared to their in the normal group. Similarly, Sanada and colleagues evaluated 1488 Japanese individuals and found that total cholesterol levels were significantly higher in those with sarcopenia compared to the normal group [32]. The potential underlying mechanism for the elevated levels total cholesterol may be associated with insulin resistance [39] and an increased volume of inflammatory cytokines [40]. These factors can lead to disturbances in lipid metabolism, contributing to total cholesterol levels in individuals with sarcopenia.

The study findings highlight that diastolic blood pressure (DBP) serve as additional susceptibility markers for wo with sarcopenia, and these results align with earlier studies conducted on sarcopenia group [41-44]. For example, Atkins et al. [42] conducted a British cohort study with 4,252 participants and observed that the sarcopenia group exhibited significantly higher DBP levels compared to the normal group. Yin et al. [44] conducted a study on 14,926 Chinese individuals and found that females with sarcopenia had significantly elevated DBP compared to normal adults. The potential mechanisms underlying the elevated DBP in women with sarcopenia involve metabolic alterations and muscle mass loss due to skeletal muscle decline. This can lead to reduced energy expenditure and physical activity, insulin resistance, and arterial stiffness in adults [45-47]. Additionally, the accumulation of visceral fat mass may trigger an inflammatory response, leading to thickening of blood vessel walls, constriction of vascular passages, and obstruction of blood flow [48]. In summary, elevated DBP are significant susceptibility markers for women with sarcopenia. The association between sarcopenia and higher blood pressure levels can be attributed to factors such as metabolic changes, muscle mass loss, insulin resistance, and the impact of visceral fat accumulation on vascular.

This study's key strength lies in its examination of female-specific susceptibility markers in a representative population of individuals in their 30s, a critical age when the decline in skeletal muscle mass typically begins. Unlike many studies that combine both sexes into a single group, this research focused solely on women, providing valuable gender-specific insights into the factors influencing sarcopenia [33,14,49].

However, it is crucial to acknowledge a limitation that should be considered in future research. The cross-sectional design utilized in this study, despite having a large sample size of participants representative of the entire population through statistical weighting, may have limitations in establishing causal relationships for the identified susceptibility markers. Cross-sectional studies only capture data at a specific point in time, making it difficult to infer causality between variables. To enhance the robustness of the findings, future studies should consider employing longitudinal or randomized case-control study designs, enabling a more comprehensive understanding of the temporal relationships and causative factors contributing to sarcopenia among the female population. In addition, Discrepancies in group sizes between sarcopenia and normal groups might cause substantial limitations to statistical analysis, potentially compromising the credibility research outcomes. Finally, the study omitted the consideration of sarcopenic obesity, a condition where individuals experience both diminished muscle mass and

heightened body fat. To better understand the outcomes, it becomes imperative to contemplate the presence of sarcopenic obesity, as it might cause better understanding in increased weight increase and expansion of waist circumference.

Ⅴ. Conclusion

This research investigation shedding light on the susceptible markers and proportion of sarcopenia among Korean females in their thirties. The study reveals that the estimated proportion of sarcopenia within this demographic is approximately 3.78%, with a confidence interval ranging from 2.89% - 4.94%). The research identifies several susceptibility markers associated with sarcopenia, such as height, weight, BMI, waist circumference, diastolic blood pressure, and total cholesterol levels. By recognizing the proportion and susceptibility markers of sarcopenia, healthcare professionals can effectively identify and detect potential sarcopenia patients in the future. Nonetheless, further research is warranted to gain a comprehensive understanding of the relationship between these predictors and sarcopenia.

References

[1] Population Division, Department of economic and social affairs. United Nations. World population aging. 2019. 11-4.

[2] Wang C, Bai L. Sarcopenia in the elderly: basic and clinical issues. Geriatr Gerontol Int. 2012;12(3):388-96.

[3] Rosenberg IH. Sarcopenia: origins and clinical relevance. J Nutr. 1997;127(5 Suppl):990S-1S.

[4] Jung HW. Visualizing domains of comprehensive geriatric assessments to grasp frailty spectrum in older adults with a radar chart. Ann Geriatr Med Res. 2020; 24(1):55-6.

[5] Dam TT, Peters KW, Fragala M, et al. An evidence-based comparison of operational criteria for the presence of sarcopenia. J Gerontol A Biol Sci Med Sci. 2014;69(5): 584-90.

[6] Htun NC, Ishikawa-Takata K, Kuroda A, et al. Screening for malnutrition in community dwelling older Japanese: preliminary development and evaluation of the Japanese nutritional risk screening tool (NRST). J Nutr Health Aging. 2016;20(2):114-20.

[7] Han K, Park YM, Kwon HS, et al. Sarcopenia as a determinant of blood pressure in older Koreans: findings from the Korea national health and nutrition examination surveys (KNHANES) 2008-2010. PLoS One. 2014;9(1): e86902.

[8] Cawthon PM, Blackwell TL, Cauley J, et al. Evaluation of the usefulness of consensus definitions of sarcopenia in older men: results from the observational osteoporotic fractures in men cohort study. J Am Geriatr Soc. 2015;63(11):2247-59.

[9] Pereira FB, Leite AF, de Paula AP. Relationship between pre-sarcopenia, sarcopenia and bone mineral density in elderly men. Arch Endocrinol Metab. 2015;59(1):59-65.

[10] Laurent MR, Dedeyne L, Dupont J, et al. Age-related bone loss and sarcopenia in men. Maturitas. 2019; 122:51-6.

[11] Reijnierse EM, de van der Schueren MAE, Trappenburg MC, et al. Lack of knowledge and availability of diagnostic equipment could hinder the diagnosis of sarcopenia and its management. PLoS One. 2017;12(10):e0185837.

[12] Mehiret G, Molla A, Tesfaw A. Knowledge on risk factors and practice of early detection methods of breast cancer among graduating students of Debre Tabor University, Northcentral Ethiopia. BMC Womens Health. 2022;22(1): 183.

[13] Stenholm S, Harris TB, Rantanen T, et al. Sarcopenic obesity-definition, etiology and consequences. Curr Opin Clin Nutr Metab Care. 2008;11(6):693.

[14] Hashemi R, Shafiee G, Motlagh AD, et al. Sarcopenia and its associated factors in Iranian older individuals: results of SARIR study. Arch Gerontol Geriatr. 2016;66:18-22.

[15] Santos VRd, Araujo MYC, Cardoso MR, et al. Association of insufficient physical activity with sarcopenia and sarcopenic obesity in individuals aged 50 years or more. Revista de Nutrição. 2017;30:175-84.

[16] Huschtscha Z, Parr A, Porter J, et al. Sarcopenic characteristics of active older adults: a cross-sectional exploration. Sports Med Open. 2021;7(1):32.

[17] Hwang J, Park S. Gender-specific risk factors and prevalence for sarcopenia among community-dwelling young-old adults. Int J Environ Res Public Health. 2022;19(12):7232.

[18] Hwang J, Park S. Sex differences of sarcopenia in an elderly asian population: the prevalence and risk factors. Int J Environ Res Public Health. 2022;19(19): 11980.

[19] Hwang J. Prevalence, anthropometric risk factors, and clinical risk factors in sarcopenic women in their 40s. J Korean Soc Phys Med. 2023;18(2):23-31.

[20] Hwang J. Age-related loss of skeletal muscle and associated risk factors in middle-aged men: a comprehensive study. J Korean Soc Phys Med. 2023; 18(2):13-21.

[21] Hwang J, Park S. Gender-specific prevalence and risk factors of sarcopenic obesity in the Korean elderly population: a nationwide cross-sectional study. Int J Environ Res Public Health. 2023;20(2):1140.

[22] Lexell J, Downham D, Sjostrom M. Distribution of different fibre types in human skeletal muscles. Fibre type arrangement in m. vastus lateralis from three groups of healthy men between 15 and 83 years. J Neurol Sci. 1986;72(2-3):211-22.

[23] Kehayias JJ, Fiatarone MA, Zhuang H, et al. Total body potassium and body fat: relevance to aging. Am J Clin Nutr. 1997;66(4):904-10.

[24] Janssen I, Heymsfield SB, Wang ZM, et al. Skeletal muscle mass and distribution in 468 men and women aged 18-88 yr. J Appl Physiol (1985). 2000;89(1):81-8.

[25] Janssen I, Heymsfield SB, Ross R. Low relative skeletal muscle mass (sarcopenia) in older persons is associated with functional impairment and physical disability. J Am Geriatr Soc. 2002;50(5):889-96.

[26] Cruz-Jentoft AJ, Bahat G, Bauer J, et al. Sarcopenia: revised European consensus on definition and diagnosis. Age Ageing. 2019;48(1):16-31.

[27] Hwang J. Unraveling the contributing factors of sarcopenia in young Korean male adults: a study of occurrence, somatometric, biochemical, and behavioral characteristics. J Korean Soc Phys Med. 2023;18(3): 21-30.

[28] Hwang J. Comprehensive investigation on the prevalence and risk factors of coexistence of age-related loss of skeletal muscle mass and obesity among males in their 40s. J Korean Soc Phys Med. 2023;18(3):1-9.

[29] Hwang J, Moon IY. Exploring incidence and potential risk factors of sarcopenic obesity among middle-aged women residing in a community. J Korean Soc Phys Med. 2023;18(3):11-9.

[30] Hwang J, Park S. A Korean nationwide cross-sectional study investigating risk factors, prevalence, and characteristics of sarcopenia in men in early old age. Healthcare. MDPI. 2023. pp.2860.

[31] Belarmino G, Gonzalez MC, Sala P, et al. Diagnosing sarcopenia in male patients with cirrhosis by dual-energy x-ray absorptiometry estimates of appendicular skeletal muscle mass. JPEN J Parenter Enteral Nutr. 2018;42(1):24-36.

[32] Sanada K, Miyachi M, Tanimoto M, et al. A cross-sectional study of sarcopenia in Japanese men and women: reference values and association with cardiovascular risk factors. Eur J Appl Physiol. 2010;110(1):57-65.

[33] Brown JC, Harhay MO, Harhay MN. Sarcopenia and mortality among a population-based sample of

community-dwelling older adults. J Cachexia Sarcopenia Muscle. 2016;7(3):290-8.

[34] Confortin SC, Meneghini V, Ono LM, et al. Anthropometric indicators as a screening tool for sarcopenia in older adults from Florianopolis, Santa Catarina: EpiFloripa Ageing study. Revista De Nutricao-Brazilian Journal of Nutrition. 2017;30(3): 287-96.

[35] Zamboni M, Mazzali G, Fantin F, et al. Sarcopenic obesity: a new category of obesity in the elderly. Nutr Metab Cardiovasc Dis. 2008;18(5):388-95.

[36] Nair KS. Aging muscle. Am J Clin Nutr. 2005; 81(5):953-63.

[37] Cesari M, Kritchevsky SB, Baumgartner RN, et al. Sarcopenia, obesity, and inflammation--results from the trial of angiotensin converting enzyme inhibition and novel cardiovascular risk factors study. Am J Clin Nutr. 2005;82(2):428-34.

[38] Du Y, Wang X, Xie H, et al. Sex differences in the prevalence and adverse outcomes of sarcopenia and sarcopenic obesity in community dwelling elderly in East China using the AWGS criteria. BMC Endocr Disord. 2019;19(1):109.

[39] Cleasby ME, Jamieson PM, Atherton PJ. Insulin resistance and sarcopenia: mechanistic links between common co-morbidities. J Endocrinol. 2016;229(2):R67-81.

[40] Schrager MA, Metter EJ, Simonsick E, et al. Sarcopenic obesity and inflammation in the InCHIANTI study. J Appl Physiol (1985). 2007;102(3):919-25.

[41] Lu CW, Yang KC, Chang HH, et al. Sarcopenic obesity is closely associated with metabolic syndrome. Obes Res Clin Pract. 2013;7(4):e301-7.

[42] Atkins JL, Whincup PH, Morris RW, et al. Sarcopenic obesity and risk of cardiovascular disease and mortality: a population-based cohort study of older men. J Am Geriatr Soc. 2014;62(2):253-60.

[43] Androga L, Sharma D, Amodu A, et al. Sarcopenia, obesity, and mortality in US adults with and without chronic kidney disease. Kidney Int Rep. 2017;2(2):201-11.

[44] Yin T, Zhang JX, Wang FX, et al. The association between sarcopenic obesity and hypertension, diabetes, and abnormal lipid metabolism in Chinese adults. Diabetes Metab Syndr Obes. 2021;14:1963-73.

[45] Ferreira I, Snijder MB, Twisk JW, et al. Central fat mass versus peripheral fat and lean mass: opposite (adverse versus favorable) associations with arterial stiffness? the amsterdam growth and health longitudinal study. J Clin Endocrinol Metab. 2004;89(6):2632-9.

[46] Snijder MB, Henry RM, Visser M, et al. Regional body composition as a determinant of arterial stiffness in the elderly: the hoorn study. J Hypertens. 2004;22(12): 2339-47.

[47] Dominguez LJ, Barbagallo M. The cardiometabolic syndrome and sarcopenic obesity in older persons. J Cardiometab Syndr. 2007;2(3):183-9.

[48] Goswami B, Reang T, Sarkar S, et al. Role of body visceral fat in hypertension and dyslipidemia among the diabetic and nondiabetic ethnic population of Tripura-A comparative study. J Family Med Prim Care. 2020;9(6): 2885-90.

[49] Therakomen V, Petchlorlian A, Lakananurak N. Prevalence and risk factors of primary sarcopenia in community-dwelling outpatient elderly: a cross-sectional study. Sci Rep. 2020;10(1):19551.