The Reference Value of Skeletal Muscle Mass Index for Defining the Sarcopenia of Women in Korea

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Background: Sarcopenia is considering important disease entity in elderly. Several study groups define the sum of the muscle masses of the four limbs as appendicular skeletal mass (ASM) to calculate skeletal muscle index (SMI). The purpose of this study was to determine cut point of SMI for sarcopenia in Korean women. Methods: This study was based on data obtained from the 2008 to 2011 Korean National Health and Nutrition Examination Survey (KNHANES) IV and V. A whole body dual energy X-ray absorptiometry scan were performed on individuals of ≥10 years old from July 2008 to May 2011. In the analysis, 11,633 women were included. ASM was calculated and SMI was obtained as ASM/height². Cutoff value was defined two standard deviations below mean values for young reference group. Results: Of 11,633 women aged 10 to 97 years, mean and standard deviation of year was 46.73 ± 18.54 years. The highest level of height was noted in 20's and the highest total sum of skeletal mass was seen 14.87 kg in 40's. The highest value of SMI was noted in 60's in Korean women. Cutoff value as mean value of young women was decided with SMI of 30's and 40's that have peak ASM. Mean and standard deviation of SMI in those ages was 5.9 ± 0.7 kg/m². A SMI of two standard deviations below the mean SMI of reference groups was 4.4 kg/m² as cutoff value. Conclusions: This study shows that 4.4 kg/m² of SMI in Korean women was cutoff value of sarcopenia. Further study is clearly required to decide cutoff value of SMI for sarcopenia, especially for Korean women.

Key Words: Diagnosis, Muscle skeletal, Sarcopenia

INTRODUCTION

The interest about sarcopenia is growing considerably. In 1989, Rosenberg[1] proposed the term ‘sarcopenia’ to describe age-related decrease of muscle mass. Sarcopenia is a syndrome characterized by progressive and generalized loss of skeletal muscle mass and strength with a risk of adverse outcomes such as physical disability, poor quality of life and death.[2,3]

Sarcopenia still has no broadly accepted clinical definition, consensus diagnostic criteria, International Classification of Diseases, Ninth Revision (ICD-9) codes or treatment guidelines. The European Working Group on Sarcopenia in Older People (EWGSOP) suggests a conceptual staging as ‘presarcopenia’, ‘sarcopenia’, ‘severe sarcopenia’. The ‘presarcopenia’ stage is characterized by low muscle mass without
impact on muscle strength or physical performance. The ‘sarcopenia’ stage is characterized by low muscle mass, plus low muscle strength or low physical performance. ‘Severe sarcopenia’ is the stage identified when all three criteria are met (low muscle mass, low muscle strength, and low physical performance). The Foundation for the National Institute of Health (FNIH) sarcopenia project defined sarcopenia as clinically relevant low muscle strength and lean mass in 2014.

There is a wide range of techniques to assess muscle mass. Three imaging techniques have been used—computed tomography (CT), magnetic resonance imaging (MRI) and dual energy X-ray absorptiometry (DXA). CT and MRI are gold standards for estimating muscle mass. However, there are several limitations in terms of cost and radiation exposure. DXA is an appropriate alternative approach to distinguish fat, bone mineral and lean tissues. Bioimpedance analysis (BIA) estimates the volume of fat and lean body mass. BIA is a noninvasive, portable, quick, and inexpensive method for measuring body composition. BIA results have been found to correlate well with MRI predictions.

EWGSOP, International Working Group in Sarcopenia (IWGS) and Asian Working Group for Sarcopenia (AWGS) guidelines define the sum of the muscle masses of the four limbs as appendicular skeletal muscle (ASM) mass to calculate skeletal muscle index (SMI) as ASM/height$^2$ (kg/m$^2$). A SMI two standard deviations below the mean SMA of young male and female reference groups was defined as cut point for sarcopenia.

EWGSOP and AWGS suggested cutoff value of female were 5.5 kg/m$^2$ and 5.4 kg/m$^2$ as cut point for sarcopenia, respectively. Therefore, the purpose of this study was to determine cut point of SMA for sarcopenia for Korean women and comparing with EWGSOP and AWGS guideline for woman.

METHODS

1. Study population

This study was based on data obtained from the 2008 to 2011 Korean National Health and Nutrition Examination Survey (KNHANES) IV and V, a nationally-representative survey conducted by the Korean Ministry of Health and Welfare. These surveys have been conducted periodically since 1998, using a rolling sampling design involving a complex, stratified, multistage, probability-cluster survey of a representative sample of the non-institutionalized civilian population in order to assess the health and nutritional status of the Korean population. A whole body DXA scan were performed on individuals ≥ 20 years old from July 2008 to June 2009 and on individuals of ≥ 10 years old from July 2009 to May 2011 (excluding pregnant women), individuals with a height of ≥ 196 cm or a weight of ≥ 136 kg were excluded in accord with the KNHANES survey protocol. In addition, test results were treated as missing value in participants with implanted radio-opaque material (e.g., a prosthetic device, implant or other radio-opaque object) that could affect DXA results. In the analysis, 11,633 women were included. Written informed consent was given by all participants and the protocol for KNHANES IV and V were approved by the Institutional Review Board of the Korean Center for Disease Control and Prevention (KCDC).

2. Definition of sarcopenia

In the KNHANES study, whole body DXA examinations were conducted with a QDR4500A apparatus (Hologic, Bedford, MA, USA). The data includes values for bone mineral content (g), bone mineral density (g/cm$^2$), fat mass (g), lean mass (including bone mineral content [g]), and fat percent for whole body and anatomical regions. From this data, ASM (kg) was calculated by summing the muscle masses of the four limbs, assuming that all non-fat and non-bone mass is skeletal muscle. SMI was defined as ASM/height$^2$. In terms of cutoff value determination, EWGSOP[4], IWGS,[9] and AWGS[8] adopt the classical approach, which is two standard deviations below mean values for young reference group. Definition of sarcopenia in this study was used two standard deviations below mean lean body mass of peak muscle mass of young women.

3. Statistical analysis

Age-groups were divided into 9 groups (10's, 20's, 30's, 40's, 50's, 60's, 70's, 80's, and 90's) and described demographics trend of ASM mass, height, SMI of each age groups. We calculated the mean lean body mass of young women of each age group and calculated incidence of sarcopenia in women. All analyses were conducted using SPSS software version 20.0 (SPSS Inc., Chicago, IL, USA).
RESULTS

KNHANES that was performed from 2008 to 2011 involves 11,633 women aged 10 to 97 years. Mean and standard deviation of year was 46.73 ± 18.54 years. Age distribution was 1,012 (8.7%) in 10’s, 1,238 (10.6%) in 20’s, 2,100 (18.1%) in 30’s, 2,068 (17.8%) in 40’s, 1,967 (16.9%) in 50’s, 1,715 (14.7%) in 60’s, 1,237 (10.6%) in 70’s, 285 (2.4%) in 80’s, 11 (0.1%) in 90’s (Table 1). The characteristics of subjects by ages are detailed in Table 2.

1. Changes of ASM mass
The mean ASM was progressively increased from 10’s to 40’s: 13.53 kg in 10’s, 14.72 kg in 20’s, 14.80 kg in 30’s, 14.87 kg in 40’s. After which the mean ASM was progressively decreased till 90’s: 14.53 kg in 50’s, 14.17 kg in 60’s, 13.28 kg in 70’s, 12.38 kg in 80’s, 11.47 kg in 90’s. Two groups that have peak mean ASM were 30’s and 40’s (Fig. 1A).

2. Changes of height
The mean height was rapidly increased by 4.2 cm from 157.2 cm in 10’s to 161.4 cm in 20’s. After 20’s, height was progressively decreased by 18.5 cm till 90’s: 159.8 cm in 30’s, 157.9 cm in 40’s, 155.7 cm in 50’s, 153.5 cm in 60’s, 150.0 cm in 70’s, 147.2 cm in 80’s, and 143.0 cm in 90’s (Fig. 1B).

3. Changes of SMI
SMI was calculated as ASM/height². The mean of SMI were 5.44 kg/m² in 10’s, 5.64 kg/m² in 20’s, 5.79 kg/m² in 30’s, 5.95 kg/m² in 40’s, 5.98 kg/m² in 50’s, 6.01 kg/m² in 60’s, 5.89 kg/m² in 70’s, 5.71 kg/m² in 80’s, and 5.62 kg/m² in 90’s (Fig. 1C). Its peak value was noted around 60’s.

4. Calculation of Korean cutoff value
Cutoff value as mean value of young women was decid-

Table 1. Distribution of subjects by ages

| Age  | Subjects | Percent (%) |
|------|----------|-------------|
| 10’ s| 1,012    | 8.7         |
| 20’ s| 1,238    | 10.6        |
| 30’ s| 2,100    | 18.1        |
| 40’ s| 2,068    | 17.8        |
| 50’ s| 1,967    | 16.9        |
| 60’ s| 1,715    | 14.7        |
| 70’ s| 1,237    | 10.6        |
| 80’ s| 285      | 2.4         |
| 90’ s| 11       | 0.1         |
| Total| 11,633   | 100         |

Table 2. Characteristics of subjects by ages

| Age  | Height (cm) | Weight (kg) | Body mass index (kg/m²) |
|------|-------------|-------------|-------------------------|
| 10’ s| 157.2 ± 8.0 | 50.4 ± 11.1 | 20.2 ± 3.4              |
| 20’ s| 161.4 ± 5.5 | 55.9 ± 9.8  | 21.4 ± 3.4              |
| 30’ s| 159.7 ± 5.3 | 57.1 ± 9.3  | 22.3 ± 3.5              |
| 40’ s| 157.9 ± 5.3 | 58.5 ± 8.7  | 23.4 ± 3.3              |
| 50’ s| 155.7 ± 5.2 | 58.8 ± 8.0  | 24.1 ± 3.1              |
| 60’ s| 153.4 ± 5.2 | 57.7 ± 8.2  | 24.4 ± 3.1              |
| 70’ s| 150.0 ± 5.5 | 54.2 ± 8.9  | 24.0 ± 3.5              |
| 80’ s| 147.2 ± 5.4 | 49.5 ± 7.9  | 22.7 ± 3.4              |
| 90’ s| 142.9 ± 6.4 | 43.1 ± 6.3  | 21.1 ± 2.4              |

Fig. 1. (A) Distribution of appendicular skeletal muscle (ASM), which indicates peak ASM in 40’s. (B) Distribution of height, which indicates sharp decrease as age increases. (C) Distribution of skeletal mass index (SMI), which indicates peak SMI in 60’s.
ed with SMI of 30’s and 40’s that have peak ASM. Mean and standard deviation of SMI in those ages was $5.9 \pm 0.7$ kg/m$^2$. A SMI two standard deviations below the mean SMI of reference groups was $4.4$ kg/m$^2$ as cutoff value.

**DISCUSSION**

Sarcopenia is well known to highly correlate with frailty and increases the risk of falling in the elderly and also represents an important risk factor for disability and mortality.\[10,11\] Recently, several study groups have been trying to make common consensus of definition, diagnosis, and treatment of sarcopenia.\[4,8,9\] In this study, demographic data of Korean women is quite different with other studies groups. We found that SMI of 30’s and 40’s had peak ASM and Mean and standard deviation of SMI in those ages was $5.9 \pm 0.7$ kg/m$^2$. Cutoff value of Korean reference groups was $4.4$ kg/m$^2$ in this study.

The cutoff point for low SMI is most widely accepted measures, as suggested by the EWGSOP and IWG. Muscle mass was assessed by DXA, which is currently considered the gold standard. In 2010, the EWGSOP has recommended using SMI values which are two standard deviations below the mean observed in young adult from the population under study. An alternate recommendation was to consider an SMI value $<-20$th percentile to define low muscle mass. EWGSOP suggested the cutoff value in women would be $5.5$ kg/m$^2$.\[4\] In 2014, the AWGS suggested $5.4$ kg/m$^2$ as the cutoff value in women. However, this study was quite different from worldwide guidelines. The cutoff point for low SMI in Korean women was $4.4$ kg/m$^2$ in this study. We think that the reason of lower the cutoff point in Korean women than other Asian countries was likely to be because the muscle mass in Koreans in their 30’s and 40’s was low, while they were taller in comparison to people within the same age group in other Asian countries.\[12-14\] Wen et al.\[15\] reported the low prevalence encountered among the Chinese population and the cutoff points for the Chinese population are lower than for Americans (4.82 vs. 5.45 in women, respectively for Chinese and North-Americans), with young people of the same ethnic group as reference. There could be lots of other reasons for these differences such as trends in physical appearances to be slim and lifestyle living with minimum of movements.

Some studies have suggested that sarcopenia is highly prevalent: 30% in the population over the age of 65 years.\[16-18\] However, when $4.4$ kg/m$^2$ was applied to older subjects ($\geq 65$) in the study group, very few was diagnosed with low SMI. In fact, SMI in 60’s was higher than one in 30’s. It is similar to other Korean studies. Kim et al.\[19\] evaluated definitions of sarcopenia to investigate the prevalence. Using same method that we used, they found the prevalence of sarcopenia lower in Koreans compared with published results in white and Hispanic populations. When sarcopenia was defined as two lower quintiles of ASM/height$^2$ in their study, the prevalence of sarcopenia was 10 times higher than using a cutoff point of two standard deviation for SMI in the young reference group. This was likely to have been caused by a big difference of height between the young reference group and the older group. The difference in height between age groups in Korea was bigger than other Asian countries.\[12,13,20\] This could be related to the fact that nutritional values have improved rapidly with the Korean economy being quickly developed in the 30 years gap.

This study has several limitations. First, this study was cross sectional design and not enough to draw enough conclusions. Second, we did not exactly exclude women who have metabolic disease such as hyperthyroidism, diabetes mellitus, and other disease, which have influenced on lean body mass. It is definitely necessary to set a cutoff value that can be widely accepted in Korea to prevent confusion. This study used most widely accepted measures and shows that $4.4$ kg/m$^2$ of SMI in Korean women was cutoff value of sarcopenia. However, using of this cutoff value as sarcopenia in women, further study is clearly mandatory because the cutoff point in this study is lower than other previous reports.

**REFERENCES**

1. Rosenberg IH. Sarcopenia: origins and clinical relevance. J Nutr 1997;127:990S-1S.
2. Delmonico MJ, Harris TB, Lee JS, et al. Alternative definitions of sarcopenia, lower extremity performance, and functional impairment with aging in older men and women. J Am Geriatr Soc 2007;55:769-74.
3. Goodpaster BH, Park SW, Harris TB, et al. The loss of skeletal muscle strength, mass, and quality in older adults: the health, aging and body composition study. J Gerontol A
4. Cruz-Jentoft AJ, Baeyens JP, Bauer JM, et al. Sarcopenia: European consensus on definition and diagnosis: report of the European Working Group on Sarcopenia in Older People. Age Ageing 2010;39:412-23.
5. Studenski SA, Peters KW, Alley DE, et al. The FNIH sarcopenia project: rationale, study description, conference recommendations, and final estimates. J Gerontol A Biol Sci Med Sci 2014;69:547-58.
6. Wang ZM, Visser M, Ma R, et al. Skeletal muscle mass: evaluation of neutron activation and dual-energy X-ray absorptiometry methods. J Appl Physiol (1985) 1996;80:824-31.
7. Chien MY, Huang TY, Wu YT. Prevalence of sarcopenia estimated using a bioelectrical impedance analysis prediction equation in community-dwelling elderly people in Taiwan. J Am Geriatr Soc 2008;56:1710-5.
8. Chen LK, LiuLK, Woo J, et al. Sarcopenia in Asia: consensus report of the Asian Working Group for Sarcopenia. J Am Med Dir Assoc 2014;15:95-101.
9. Fielding RA, Vellas B, Evans WJ, et al. Sarcopenia: an undiagnosed condition in older adults. Current consensus definition: prevalence, etiology, and consequences. International working group on sarcopenia. J Am Med Dir Assoc 2011;12:249-56.
10. Chastin SF, Ferriolli E, Stephens NA, et al. Relationship between sedentary behaviour, physical activity, muscle quality and body composition in healthy older adults. Age Ageing 2012;41:111-4.
11. Landi F, Liperoti R, Fusco D, et al. Sarcopenia and mortality among older nursing home residents. J Am Med Dir Assoc 2012;13:121-6.
12. Lim TO, Ding LM, Zaki M, et al. Distribution of body weight, height and body mass index in a national sample of Malaysian adults. Med J Malaysia 2000;55:108-28.
13. Cheng Q, Zhu X, Zhang X, et al. A cross-sectional study of loss of muscle mass corresponding to sarcopenia in healthy Chinese men and women: reference values, prevalence, and association with bone mass. J Bone Miner Metab 2014;32:78-88.
14. Marwaha RK, Garg MK, Bhadra K, et al. Assessment of lean (muscle) mass and its distribution by dual energy X-ray absorptiometry in healthy Indian females. Arch Osteoporos 2014;9:186.
15. Wen X, Wang M, Jiang CM, et al. Are current definitions of sarcopenia applicable for older Chinese adults? J Nutr Health Aging 2011;15:847-51.
16. Baumgartner RN, Koehler KM, Gallagher D, et al. Epidemiology of sarcopenia among the elderly in New Mexico. Am J Epidemiol 1998;147:755-63.
17. Iannuzzi-Sucich M, Prestwood KM, Kenny AM. Prevalence of sarcopenia and predictors of skeletal muscle mass in healthy, older men and women. J Gerontol A Biol Sci Med Sci 2002;57:M772-7.
18. Cawthon PM, Marshall LM, Michael Y, et al. Frailty in older men: prevalence, progression, and relationship with mortality. J Am Geriatr Soc 2007;55:1216-23.
19. Kim TN, Yang SJ, Yoo HJ, et al. Prevalence of sarcopenia and sarcopenic obesity in Korean adults: the Korean sarcopenic obesity study. Int J Obes (Lond) 2009;33:885-92.
20. Kim S, Won CW, Kim BS, et al. The association between the low muscle mass and osteoporosis in elderly Korean people. J Korean Med Sci 2014;29:995-1000.
