JAMDA 15 (2014) 95–101

JAMDA

journal homepage: www.jamda.com

Review

Sarcopenia in Asia: Consensus Report of the Asian Working Group for Sarcopenia

Liang-Kung Chen MD, PhD [a,*], Li-Kuo Liu MD, PhD [a], Jean Woo MD [b], Prasert Assantachai MD, PhD [c], Tung-Wai Auyeung MD [b], Kamaruzzaman Shahrul Bahyah MD [d], Ming-Yueh Chou MD [e], Liang-Yu Chen MD [a], Pi-Shan Hsu MD [f], Orapitchaya Krairit MD [g], Jenny S.W. Lee MD [b], Wei-Ju Lee MD, MSc [h], Yunhwan Lee MD, PhD [i], Chih-Kuang Liang MD [e], Panita Limpawattana MD, PhD [j], Chu-Sheng Lin MD [k], Li-Ning Peng MD, MSc [a], Shosuke Satake MD, PhD [l], Takao Suzuki MD, PhD [m], Chang Won Won MD, PhD [n], Chih-Hsing Wu MD [o], Si-Nan Wu MD [p], Teimei Zhang MD, PhD [p], Ping Zeng MD [p], Masahiro Akishita MD, PhD [q], Hidenori Arai MD, PhD [r,*]

[a] *Center for Geriatrics and Gerontology, Taipei Veterans General Hospital, Taipei, Taiwan*
[b] *The S H Ho Centre for Gerontology and Geriatrics, The Chinese University of Hong Kong, Hong Kong, China*
[c] *Department of Preventive and Social Medicine, Siriraj Hospital, Mahidol University, Bangkok, Thailand*
[d] *Department of Medicine, University of Malaya, Kuala Lumpur, Malaysia*
[e] *Geriatric Medicine Center, Kaohsiung Veterans General Hospital, Kaohsiung, Taiwan*
[f] *Department of Family Medicine, Taichung Hospital, Ministry of Health and Welfare, Taichung, Taiwan*
[g] *Department of Internal Medicine, Ramathibodi Hospital, Mahidol University, Bangkok, Thailand*
[h] *Department of Family Medicine, Taipei Veterans General Hospital Yuanshan Branch, I-Land, Taiwan*
[i] *Department of Preventive Medicine and Public Health, Ajou University School of Medicine, Suwon, South Korea*
[j] *Department of Medicine, Faculty of Medicine, Khon Kaen University, Khon Kaen, Thailand*
[k] *Center for Geriatrics and Gerontology, Taichung Veterans General Hospital, Taichung, Taiwan*
[l] *Department of Comprehensive Geriatric Medicine, National Center for Geriatrics and Gerontology, Obu, Japan*
[m] *Research Institute, National Center for Geriatrics and Gerontology, Obu, Japan*
[n] *Department of Family Medicine, Kyung Hee University School of Medicine, Seoul, South Korea*
[o] *Department of Family Medicine, National Cheng Kung University Hospital and College of Medicine, Tainan, Taiwan*
[p] *Beijing Institute of Geriatrics, Beijing Hospital, Ministry of Health, Beijing, China*
[q] *Department of Human Health Sciences, Kyoto University Graduate School of Medicine, Kyoto, Japan*
[r] *Department of Geriatric Medicine, Graduate School of Medicine, University of Tokyo, Tokyo, Japan*

Keywords:
Sarcopenia
frailty
muscle mass
muscle quality
muscle strength
physical performance

A B S T R A C T

Sarcopenia, a newly recognized geriatric syndrome, is characterized by age-related decline of skeletal muscle plus low muscle strength and/or physical performance. Previous studies have confirmed the association of sarcopenia and adverse health outcomes, such as falls, disability, hospital admission, long term care placement, poorer quality of life, and mortality, which denotes the importance of sarcopenia in the health care for older people. Despite the clinical significance of sarcopenia, the operational definition of sarcopenia and standardized intervention programs are still lacking. It is generally agreed by the different working groups for sarcopenia in the world that sarcopenia should be defined through a combined approach of muscle mass and muscle quality, however, selecting appropriate diagnostic cutoff values for all the measurements in Asian populations is challenging. Asia is a rapidly aging region with a huge population, so the impact of sarcopenia to this region is estimated to be huge as well. Asian Working Group for Sarcopenia (AWGS) aimed to promote sarcopenia research in Asia, and we collected the best available evidences of sarcopenia researches from Asian countries to establish the consensus for sarcopenia diagnosis. AWGS has agreed with the previous reports that sarcopenia should be described as

The authors declare no conflicts of interest.

* Address correspondence to Liang-Kung Chen, MD, PhD, Center for Geriatrics and Gerontology, Taipei Veterans General Hospital, No. 201, Sec 2, Shihpai Road, Taipei, Taiwan; or Hidenori Arai, MD, PhD, Department of Human Health Sciences, Kyoto University Graduate School of Medicine, 53 Kawahara-cho, Shogoin, Sakyo-ku 606-8507, Kyoto, Japan.
E-mail addresses: lkchen2@vghtpe.gov.tw (L.-K. Chen), harai@kuhp.kyoto-u.ac.jp (H. Arai).

http://dx.doi.org/10.1016/j.jamda.2013.11.025

low muscle mass plus low muscle strength and/or low physical performance, and we also recommend outcome indicators for further researches, as well as the conditions that sarcopenia should be assessed. In addition to sarcopenia screening for community-dwelling older people, AWGS recommends sarcopenia assessment in certain clinical conditions and healthcare settings to facilitate implementing sarcopenia in clinical practice. Moreover, we also recommend cutoff values for muscle mass measurements (7.0 kg/m^2 for men and 5.4 kg/m^2 for women by using dual X-ray absorptiometry, and 7.0 kg/m^2 for men and 5.7 kg/m^2 for women by using bioimpedance analysis), handgrip strength (<26 kg for men and <18 kg for women), and usual gait speed (<0.8 m/s). However, a number of challenges remained to be solved in the future. Asia is made up of a great number of ethnicities. The majority of currently available studies have been published from eastern Asia, therefore, more studies of sarcopenia in south, southeastern, and western Asia should be promoted. On the other hand, most Asian studies have been conducted in a cross-sectional design and few longitudinal studies have not necessarily collected the commonly used outcome indicators as other reports from Western countries. Nevertheless, the AWGS consensus report is believed to promote more Asian sarcopenia research, and most important of all, to focus on sarcopenia intervention studies and the implementation of sarcopenia in clinical practice to improve health care outcomes of older people in the communities and the healthcare settings in Asia.

Sarcopenia has been accepted as a new geriatric syndrome,[1] and the knowledge related to sarcopenia is growing rapidly worldwide. Over the past 20 years of sarcopenia research after the first introduction by Rosenberg et al,[2] the etiology, pathophysiology, risk factors, and consequences of sarcopenia have gradually become clearer.[3] Moreover, a number of therapeutic approaches and clinical trials have been developed and are still evolving.[4–7] Most importantly, the association of sarcopenia with poorer health status and adverse outcomes had triggered a new approach for health promotion and health care of older people. The escalation of elderly population worldwide further strengthened the clinical importance of sarcopenia, which is even more significant in Asia because of the rapid demographic transition in this highly populated continent.[8–10]

Sarcopenia has been described as an age-related decline in skeletal muscle mass as well as muscle function (defined by muscle strength or physical performance),[11] which may result in reduced physical capability,[12–14] poorer quality of life, impaired cardiopulmonary performance,[15,16] unfavorable metabolic effects,[17] falls,[18] disability, and mortality in older people,[19,20] as well as high health care expenditure.[21] Furthermore, sarcopenia is also associated with multimorbidity,[22,23] cigarette smoking,[22,24] low body mass index,[25] underweight,[26] physical inactivity,[12] and low serum levels of testosterone in men.[27,28] In general, the association between sarcopenia and functional decline is more significant in men than in women,[29,30] which deserves further research for therapeutic consideration. Since Asia is the most populated and fastest aging region in the world, sarcopenia will pose great impacts to Asian populations in the near future.[31,32] Therefore, experts and researchers of sarcopenia from China, Hong Kong, Japan, South Korea, Malaysia, Taiwan, and Thailand organized the Asian Working Group for Sarcopenia (AWGS) and had several meetings in Taipei, Seoul, and Kyoto to promote further research development of sarcopenia in Asia since March 2013. This article will focus on the epidemiology of sarcopenia in Asian countries and to propose a diagnostic algorithm based on currently available evidence in Asia.

Diagnosis of Sarcopenia and Its Impact to Asia

Asia is a huge and densely populated continent with a wide range of ethnicities, cultural, social, religious backgrounds, and lifestyles. Because of the rapid population aging and the population size, the impact of sarcopenia in Asia may be stronger than in other continents. However, the status of population aging and economic development varies extensively in different Asian countries. Therefore, developing a consensus for sarcopenia diagnosis and clinical approaches based on available evidence is of great importance for sarcopenia research in the future.

In 2010, European Working Group on Sarcopenia in Older People (EWGSOP) proposed an operational definition and diagnostic strategy for sarcopenia that had become the most widely used in the world.[33] The EWGSOP definition required measurements of muscle mass, muscle strength, and physical performance for the diagnosis of sarcopenia, which is compatible with current understanding about sarcopenia. Based on the discussion of the AWGS meetings, we decided to take similar approaches for sarcopenia diagnosis, but unlike EWGSOP, we recommended measuring both muscle strength (handgrip strength) and physical performance (usual gait speed) as the screening test (Figure 1). Although the recommended approaches for measurements of muscle mass, muscle strength, and physical performance by AWGS were similar to the EWGSOP definition, the cutoff values of these measurements in Asian populations may differ from those in Caucasians because of ethnicities, body size, lifestyles, and cultural backgrounds. Therefore, developing an Asian consensus in sarcopenia diagnosis based on the evidence derived from Asian populations is essential for research and therapeutic approaches to sarcopenia in Asia.

Strategy for Sarcopenia Screening and Assessment

In principle, AWGS followed the diagnostic approach of EWGSOP, and we added some Asian perspectives in sarcopenia diagnosis and research. In the previous studies from Western countries, the prevalence of sarcopenia in older people was around 20% among people aged 65 years and older and may reach 50%–60% in octogenarians.[34] EWGSOP recommends routine screening for sarcopenia among community-dwelling people aged 65 years and older. On the other hand, the International Working Group on Sarcopenia (IWGS) specifies certain conditions for sarcopenia assessment, including (1) noted decline in function, strength, "health" status, (2) self-reported mobility-related difficulty, (3) history of recurrent falls, (4) recent unintentional weight loss (>5%), (5) post-hospitalization, and (6) other chronic conditions (eg, type 2 diabetes, chronic heart failure, chronic obstructive pulmonary disease, chronic kidney disease, rheumatoid arthritis, and cancer).[35] Moreover, IWGS recommends assessing patients with reduced physical functioning (or weakness) or patients with habitual gait speed <1.0 m/s (by 4-m course) to assess body composition by dual x-ray absorptiometry (DXA). Nonambulatory patients or those who cannot rise from a chair unassisted should be considered to be sarcopenic without DXA measurements. Since sarcopenia is defined as an age-related condition, assessment of sarcopenia is limited to people aged 65 years and older only in the

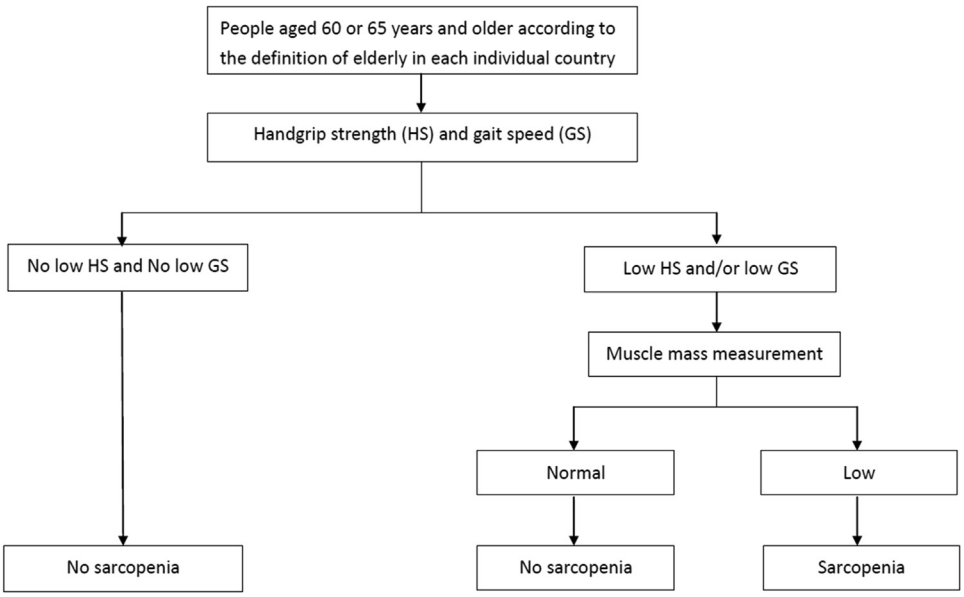

Fig. 1. Recommended diagnostic algorithm of Asian Working Group for Sarcopenia.

EWGSOP criteria, but IWGS does not specify the age for sarcopenia diagnosis.

In Asia, because of the different states of aging, not all countries use the same age cutoff to define elderly populations. Therefore, AWGS recommends using 60 or 65 years as the age for sarcopenia diagnosis according to the definitions of elderly in each country. Although muscle aging is a continuous process, most previous studies supported the idea that loss of muscle mass and muscle strength becomes pronounced around the age of 50,[36] progresses faster after the age of 60,[37] and accelerates even faster after the age of 75.[38] The overall benefits of sarcopenia screening or assessment programs are dependent on the outcomes of effective intervention programs. AWGS emphasizes the benefits of intervention programs in addition to sarcopenia screening and assessment; therefore, we recommend screening for sarcopenia among community-dwelling older people as well as older people with certain clinical conditions in all healthcare settings. Table 1 summarized the recommended strategy for sarcopenia screening and assessment of AWGS by dividing cases into 2 categories (ie, community settings and specific chronic conditions in all healthcare settings). From the perspective of public health, sarcopenia screening for community-dwelling older people would facilitate health promotion and disability prevention in their communities, and the assessment of sarcopenia in clinical settings would facilitate strategies for the intervention in clinical practice. AWGS would like to emphasize the prognostic significance of sarcopenia in clinical practice through assessment under certain clinical conditions. However, the benefits of identification of and interventions for sarcopenia remain to be determined.

Table 1
Strategy of Sarcopenia Screening and Assessment for Older People (60 or 65 Years of Age and Older) in Asia

Community Settings
People aged 60 or 65 years and older (according to the definitions of elderly in each individual country) living in communities
Specific Clinical Conditions in All Healthcare Settings
Presence of recent functional decline or functional impairment Unintentional body weight loss for over 5% in a month Depressive mood or cognitive impairment Repeated falls Undernutrition Chronic conditions (eg, chronic heart failure, chronic obstructive pulmonary disease, diabetes mellitus, chronic kidney disease, connective tissue disease, tuberculosis infection, and other chronic wasting conditions)

Suggested Outcome Indicators in Sarcopenia Research

The EWGSOP definition suggests using physical performance, muscle strength, and muscle mass as the primary treatment outcome indicators for sarcopenia intervention trials, whereas activities of daily living, quality of life, metabolic and biochemical markers, inflammatory markers, global impression of change by subject or physician, falls, admission to nursing home or hospital, social support, and mortality as secondary outcome indicators.[33] While most epidemiologic studies in sarcopenia research to date have taken a static approach, the state of sarcopenia may change over time and this dynamic approach may provide different considerations in developing sarcopenia intervention programs. Therefore, AWGS also recommends a dynamic approach for sarcopenia research by measuring changes in (1) muscle mass, strength, and function, (2) physical performance, (3) frailty status, (4) instrumental activities of daily living, and (5) basic activities of daily living over a given period of time as outcome indicators for sarcopenia research. In addition to the above-mentioned outcome indicators, AWGS also recommends using fear of falling and incontinence as outcome indicators for sarcopenia research (Table 2).

Assessment Techniques and Suggested Cutoff Values

Assessment of sarcopenia in Asian populations presents a great challenge because of the lack of outcome-based studies. However, determining appropriate cutoff values for sarcopenia diagnosis in Asia is critical to promote further sarcopenia research and treatment in Asia. Consequently, AWGS focused on the best available evidence to determine cutoff values for the diagnosis of sarcopenia in Asia. If, however, no outcome-based data are available, AWGS would recommend standardized approaches for cutoff value determination.

Table 2
Outcome Indicators for Sarcopenia Research Recommended by AWGS

Static Approach
Activities of daily living
Quality of life
Inflammatory markers
Falls
Frailty status
Mobility disorders
Admission to hospitals
Admission to long term care facilities
Mortality
Dynamic Approach
Changes in muscle mass
Changes in muscle strength
Changes in physical performance
Changes in frailty status
Changes in instrumental activities of daily living
Changes in activities of daily living

AWGS, Asian Working Group for Sarcopenia.

Muscle Mass

EWGSOP recommends DXA, computed tomography (CT), magnetic resonance imaging (MRI), and bioimpedance analysis (BIA) for sarcopenia research. Currently, the precision of DXA, CT, and MRI has been well recognized, but the precision of BIA in measuring muscle mass is controversial. BIA was developed to estimate the volume of body fat and lean body mass, but not appendicular muscle mass. Although the accuracy of BIA in sarcopenia diagnosis has been validated,[39–41] it is heavily dependent on the accuracy of the equation of the equipment and the conditions of assessments, eg, temperature, humidity, skin condition, etc.[42] Nevertheless, the high cost, CT-generated radiation exposure, and inconvenience for community screening have limited the applications of CT and MRI despite both CT and MRI have both been considered gold standards for evaluation of body composition. On the other hand, DXA is also considered an appropriate alternative approach to distinguish between fat, bone mineral, and lean tissues. Currently, DXA may be the most widely used method for muscle mass measurement in sarcopenia research. Despite the minimal radiation exposure from DXA, using DXA in community screening of sarcopenia is still difficult. Newly developed models of BIA equipment may obtain measurements of appendicular muscle mass with precision.[43,44] Portability, reasonable cost, fast processing, noninvasiveness, radiation-free functions, and convenience of use made BIA suitable for community sarcopenia assessment. Results of multiple segment fat-free mass estimation using BIA are highly associated with that measured using DXA among elderly Taiwanese.[45] Although using BIA equipment with validated equations is recommended for sarcopenia research in EWGSOP criteria, the equations of BIA equipment in Western countries are not derived from Asian populations. Strasser et al[46] proposed measurement of muscle thickness, especially of musculus vastus medialis, by musculoskeletal ultrasound to be a reliable method for the estimation of sarcopenia, which deserves further research for applications in Asian studies. In current Asian studies, the most commonly used BIA machines were manufactured by only 2 companies, and the results were quite consistent. Because of its portability and reasonable cost, BIA may be considered the main approach in sarcopenia assessment in community-based screening programs. Therefore, AWGS supports using BIA for sarcopenia diagnosis and evaluation of the effect of intervention programs, but AWGS suggests researchers to provide coefficient of variance, inter- and intra-examiner reliability whenever possible to facilitate subsequent international comparisons.

In terms of cutoff value determination, most current Asian studies have adopted the classical approach for muscle mass measurement (ie, below 2 standard deviations of the mean muscle mass of young adults). However, Asian studies reported an extremely low prevalence of sarcopenia through this approach, especially in older women.[26,47,48] Lau et al[26] also found that the relative total skeletal muscle of Hong Kong Chinese (total skeletal muscle /height^2) was 17% lower among young Chinese men than that of Caucasian men.[26] A potential cohort effect may exist in this approach since younger people in Asia today leading a westernized or more urbanized lifestyle while older Asian people have carried out a traditional lifestyle since adulthood. This cohort effect may be derived from the economic development, urbanization, and development of public transportation in Asia in recent decades. Older Asian people today may have walked and performed more physical activities because of the underdevelopment of public transportation and living conditions since their early adulthood, so their muscle mass may be maintained better than that of the younger generation. On the other hand, because of the relatively higher adiposity of Asian people in comparison with Caucasians, appendicular muscle mass may be overestimated by DXA. Overall, AWGS recommends using 2 standard deviations below the mean muscle mass of young reference group or the lower quintile as the cutoff value determination. Moreover, AWGS recommends using height-adjusted skeletal muscle mass instead of weight-adjusted skeletal muscle mass, and the suggested cutoff values were 7.0 kg/m^2 in men and 5.4 kg/m^2 in women by using DXA. By using BIA, the suggested cutoff values were 7.0 kg/m^2 in men and 5.7 kg/m^2 in women, defined by appendicular skeletal muscle mass/height^2.

Muscle Strength

Measuring handgrip strength is considered a feasible and convenient measure of muscle strength because of cost, availability, ease of use, and its association with leg strength. Wu et al[49] presented the norm of handgrip strength in Taiwan, which disclosed that the mean grip strength of the study sample in Taiwan was significantly lower (male 25%, female 27%) than consolidated norms derived from largely Caucasian populations. Although some papers published in Taiwan using this adjusted cutoff value based on EWGSOP definition for sarcopenia research,[50] some unpublished papers from Japan, Hong Kong, and China recommended using 25 kg for men and 18 or 16 kg for women as the cutoff values for handgrip strength. Currently, handgrip strength is the most widely used measure for muscle strength in Asian sarcopenia research (Table 3), and AWGS also recommends using it for the measurement of muscle strength. Although knee flexion/extension and peak expiratory flow are also recommended for sarcopenia research in EWGSOP criteria, they are less commonly used. In Thailand, the cutoff points of quadriceps strength had been defined based on the outcome of mobility decline. The cutoff points of $<$18 kg in men and $<$16 kg in women can discriminate those had normal and abnormal various sarcopenia-related variables. Because of the lack of outcome-based cutoff values, AWGS recommends using the lower 20th percentile of handgrip strength of the study population as the cutoff value for low muscle strength before outcome-based data is available. Low handgrip strength is suggested to be defined as $<$26 kg for men and $<$18kg for women by AWGS.

Physical Performance

A wide range of tests for physical performance are recommended in EWGSOP criteria, including the Short Physical Performance Battery (SPPB), usual gait speed, the 6-minute walk test, the stair climb power test, and the timed-up-and-go test (TUG).[51] Timed usual gait is highly predictive for the onset of disability,[52] and other adverse health

Table 3
Measurable Variables and Cutoff Points in Asian Populations

Criterion	Measurement Method	Cutoff Points by Sex	Reference Group Definition	Prevalence of Sarcopenia	Country/ Ethnicity	Reference
Muscle mass	DXA	ASM/height^2 Class 1 and class 2 sarcopenia Men: 7.77 and 6.87 kg/m^2 Women: 6.12 and 5.46 kg/m^2	Based on values 1 and 2 SD below the sex-specific means of the study reference data (n = 529)	Class 1 and class 2 sarcopenia in subjects 70–85 years of age: Men: 6.7%, 56.7% Women: 6.3%, 33.6%	Japan	69
		ASM/height^2 Men <5.72 kg/m^2 Women <4.82 kg/m^2	Based on 2 SD below the mean of young Asians in study (n = 111)	In older Chinese ≥70 years of age Men: 12.3% Women: 7.6%	Chinese	26
		ASM/height^2 Men: 7.40 kg/m^2 Women: 5.14 kg/m^2	Based on 2 SD below the sex-specific mean of a younger population (n = 145)	In older subjects ≥ 60 years of age Men: 6.3% Women: 4.1%	Korea	70
		SMI (%)[†] Men: 35.71% Women: 30.70%	Based on 2 SD below the sex-specific mean of a younger population (n = 145)	Men: 5.1% Women: 14.2%		
		Using the residuals method		Men: 15.4% Women: 22.3%		
		ASM/height^2 Class I and class II sarcopenia Men: 7.50 and 6.58 kg/m^2 Women: 5.38 and 4.59 kg/m^2	Based on 1 and 2 SD below the mean of young adults in study (n = 2513)	Class I and class II sarcopenia Men: 30.8% and 12.4% Women: 10.2% and 0.1%	Korea	48
		ASM/body weight (%) Class I and class II sarcopenia Men: 32.2% and 29.1% Women: 25.6% and 23.0%	Based on 1 and 2 SD below the mean of young adults in study	Men: 29.5% and 9.7% Women: 30.3% and 11.8%	Korea	48
		ASM/body weight (%)[‡] Men: 29.53% Women: 23.20%	Based on 2 SD of sex-specific young normal people		Korea	71
		Use SMI (% of skeletal muscle index) but not mentioned the cutoff points in the manuscript	Based on 2 SD of sex-specific young normal people	Sarcopenia class I, II, overall Men: 32.5%, 15.7%, 35.33 % Women: 30.5%, 10%, 34.74 %	Thailand	72
		RASM index Men: 7.27 kg/m^2 Women: 5.44 kg/m^2	Based on the lower 20% of study group	Men: 10.8% Women: 3.7%	Taiwan	47
		SMI (% of skeletal muscle index) Men: 37.4% Women: 28.0%	Based on the lower 20% of study group	Men: 14.9% Women: 19%		
	BIA	SMI Men <8.87 kg/m^2 Women <6.42 kg/m^2	Based on 2 SD below the normal sex-specific mean for young people	18.6% in elderly women and 23.6% in elderly men age 65 and older	Taiwan	40
		ASM/height^2 Men <7.0 kg/m^2 Women <5.8 kg/m^2	Based on 2 SD below young adult values	Men: 11.3% Women: 10.7% using EWGSOP criteria	Japan	13
		ASM/height^2 Women ≤ 6.42 kg/m^2		Women: 22.1%	Japan	6
		ASM/height^2 Men <6.75 kg/m^2 Women <5.07 kg/m^2	Based on 2 SD below young adult values	Men: 21.8% Women: 22.1% using EWGSOP criteria	Korea/Health ABC data	15
Muscle strength	Handgrip strength	Men: 30.3 kg Women: 19.3 kg	Based on lowest quartile of study group		Japan	13
		Men <22.4 kg Women <14.3 kg	Based on EWGSOP recommendation and adjusted according to Asian data[49]		Taiwan	50
	Knee extension	Women ≤1.01 Nm/kg			Japan	6,73
Physical performance	Gait speed	Gait speed Men <1.27 m/s Women <1.19 m/s	Based on the lowest quartile of study group, gait speed obtained from the middle 5 m of a total of 11 m walking	Men: 11.3% Women: 10.7% using EWGSOP criteria	Japan	13
		Gait speed ≤ 1 m/s			Taiwan	50
		Gait speed ≤ 1.22 m/s		Women: 22.1%	Japan	6,73
	SPPB	SPPB scores <9			Korea	74

ASM, appendicular skeletal muscle mass; BIA, bioimpedance analysis; DXA, dual x-ray absorptiometry; EWGSOP, European Working Group on Sarcopenia in Older People; Health ABC, The Health Aging and Body Composition Study; RASM, relative appendicular skeletal muscle; SD, standard deviation; SPPB, Short Physical Performance Battery; SMI, skeletal muscle mass index.

[†]SMI (%) = total skeletal muscle mass (kg)/weight (kg) × 100.

[‡]The author also named it modified skeletal muscle mass index (SMI).

events like severe mobility limitation and mortality.[53] TUG is an assessment of ambulation and dynamic balance. Poorer TUG has been demonstrated to be associated with poorer physical and mental function and mood status, as well as low fat-free mass by BIA measurements.[54] Although TUG has been proposed as a suitable measurement for physical performance in EWGSOP, abnormal TUG may result from a great variety of underlying conditions. AWGS is more conservative in the use of TUG as a measurement for physical

performance, and we recommend using 6-meter usual gait speed for measurement of physical performance.

Ideally, determination of the cutoff values of these measurements should be based on longitudinal outcome-based studies instead of a simply statistical approach.[55] Although the association between sarcopenia and functional decline or even mortality has been established,[56] selection of universal outcome indicators in subsequent research may facilitate international comparisons. Table 3 summarized the epidemiology and proposed cut-off points in different cases of Asian sarcopenia research. EWGSOP has developed a suggested algorithm based on gait speed measurement with a cutoff point of $<$0.8 m/s.[33] The association of slow usual gait speed in the elderly with adverse clinical outcomes has been reported extensively, but the application was also dependent on the determination of appropriate cutoff points. Meanwhile, the prevalence of low muscle mass in the Asian population as determined using the classical approach is very low, which is confusing. The potential cohort effect may partially explain the phenomenon of older people today engaging in more physical activities than younger people, which made the prevalence of sarcopenia lower than expected. Specific consideration of this potential cohort effect deserves further attention in the diagnosis of sarcopenia in Asia. Although there is a potential gender difference in the cutoff value of usual gait speed and a wide range of walking speed (from 0.6 to 1.2 m/s) being reported in this special issue, AWGS suggested using $\leq$0.8 m/s as the cutoff for low physical performance after extensive consideration of data available in Asian studies.

Therapeutic Implications

Physical activities, including aerobics, endurance exercise,[57] and resistance exercise training[58,59] have been demonstrated to significantly increase muscle mass and strength in sarcopenic older people. Although the recommended frequency of exercise training to improve muscle strength and functional performance has been shown,[60] a consensus has not yet been reached concerning the content of the prescribed exercise and the most optimal frequency and intensity. Inappropriate exercise training in the elderly may result in unfavorable adverse outcomes such as musculoskeletal complaints,[61] which is not uncommon. Further research should be focused on the development of suitable exercise prescription, especially for older people at risk of functional decline or sarcopenia. The Society for Sarcopenia, Cachexia, and Wasting Disease developed nutritional recommendations for the prevention and management of sarcopenia, which combined exercise with adequate protein and energy intake.[62] A leucine-enriched balanced essential amino acid or balanced amino acid supplementation is suggested for sarcopenia. Recently, Kim et al[6] demonstrated that exercise and amino acid supplementation (3 g of a leucine-rich essential amino acid mixture twice a day) together may actually be effective in enhancing muscle strength, variables of muscle mass, and walking speed in sarcopenic women. Aside from exercise and nutritional supplementation, the pharmaceutical approach to sarcopenia is still under development. Growth hormone replacement was not successful because the effect of increased muscle mass by growth hormone replacement was not associated with the improvement of muscle performance,[63–65] unless it is used for growth hormone deficiency patients for a period longer than 12 months.[66–68] In addition, the effects of antimyostatin antibodies on sarcopenia have been demonstrated and may be marketed in a few years. Therefore, sarcopenia should be treated through a multilevel approach employing combined physical activities and nutritional supplementation. Currently, there is no well-established evidence for pharmaceutical approach for sarcopenia intervention, but a few agents may be available in future.

Future Challenge and Conclusion

Sarcopenia significantly impacts daily activities, functional status, disability, and quality of life in older populations. Although Asian populations are rapidly ageing, from the clinical practice or public health points of view, the understanding of and preparation for sarcopenia remain inadequate. Hence, this consensus collected as many Asian studies as possible and offers a working diagnosis of sarcopenia for Asian people. The main aims of AWGS were to promote sarcopenia research in Asian countries through providing recommended diagnostic strategies and cutoff values based on Asian studies, and to foster the importance of implementing sarcopenia in clinical practice and in community health promotion programs.

References

1. Cruz-Jentoft AJ, Landi F, Topinkova E, Michel JP. Understanding sarcopenia as a geriatric syndrome. Curr Opin Clin Nutr Metab Care 2010;13:1–7.
2. Rosenberg IH. Summary comments. Am J Clin Nutr 1989;50:1231S–1233S.
3. Rolland Y, Czerwinski S, Abellan Van Kan G, et al. Sarcopenia: Its assessment, etiology, pathogenesis, consequences and future perspectives. J Nutr Health Aging 2008;12:433–450.
4. Barillaro C, Liperoti R, Martone AM, et al. The new metabolic treatments for sarcopenia. Aging Clin Exp Res 2013;25:119–127.
5. Aleman-Mateo H, Macias L, Esparza-Romero J, et al. Physiological effects beyond the significant gain in muscle mass in sarcopenic elderly men: Evidence from a randomized clinical trial using a protein-rich food. Clin Intervent Aging 2012;7:225–234.
6. Kim HK, Suzuki T, Saito K, et al. Effects of exercise and amino acid supplementation on body composition and physical function in community-dwelling elderly Japanese sarcopenic women: A randomized controlled trial. J Am Geriatr Soc 2012;60:16–23.
7. Elkina Y, von Haehling S, Anker SD, Springer J. The role of myostatin in muscle wasting: An overview. J Cachexia Sarcopenia Muscle 2011;2:143–151.
8. United Nations DoEaSA, Population Division, (2013). World Population Prospects: The 2012 Revision, Key Findings and Advance Tables: Working Paper No. ESA/P/WP.227.
9. Chen LK. Population ageing is a global phenomenon, which affects both Taiwan and China. Preface. Ageing Res Rev 2010;9:S1.
10. Chen LK, Inoue H, Won CW, et al. Challenges of urban aging in Taiwan: Summary of urban aging forum. J Clin Gerontol Geriatr 2013;4:97–101.
11. Delmonico MJ, Harris TB, Visser M, et al. Longitudinal study of muscle strength, quality, and adipose tissue infiltration. Am J Clin Nutr 2009;90:1579–1585.
12. Woo J, Leung J, Sham A, Kwok T. Defining sarcopenia in terms of risk of physical limitations: A 5-year follow-up study of 3,153 chinese men and women. J Am Geriatr Soc 2009;57:2224–2231.
13. Tanimoto Y, Watanabe M, Sun W, et al. Association between sarcopenia and higher-level functional capacity in daily living in community-dwelling elderly subjects in Japan. Arch Gerontol Geriatr 2012;55:e9–e13.
14. Auyeung TW, Lee JSW, Leung J, et al. The selection of a screening test for frailty identification in community-dwelling older adults. J Nutr Health Aging on-line September 2013 available http://dx.doi.org/10.1007/s12603-013-0365-4. Online ISSN 1760–4788.
15. 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 Biol Sci Med Sci 2006;61:1059–1064.
16. Lim S, Kwon SY, Yoon JW, et al. Association between body composition and pulmonary function in elderly people: The Korean Longitudinal Study on Health and Aging. Obesity (Silver Spring) 2011;19:631–638.
17. Karakelides H, Nair KS. Sarcopenia of aging and its metabolic impact. Curr Top Dev Biol 2005;68:123–148.
18. Yamada M, Nishiguchi S, Fukutani N, et al. Prevalence of Sarcopenia in Community-Dwelling Japanese Older Adults. J Am Med Dir Assoc 2013;14:911–915.
19. Cesari M, Pahor M, Lauretani F, et al. Skeletal muscle and mortality results from the InCHIANTI Study. J Gerontol A Biol Sci Med Sci 2009;64:377–384.
20. Newman AB, Kupelian V, Visser M, et al. Strength, but not muscle mass, is associated with mortality in the health, aging and body composition study cohort. J Gerontol A Biol Sci Med Sci 2006;61:72–77.
21. Janssen I, Shepard DS, Katzmarzyk PT, Roubenoff R. The healthcare costs of sarcopenia in the United States. J Am Geriatr Soc 2004;52:80–85.
22. Lee JS, Auyeung TW, Kwok T, et al. Associated factors and health impact of sarcopenia in older chinese men and women: A cross-sectional study. Gerontology 2007;53:404–410.
23. Park SW, Goodpaster BH, Lee JS, et al. Excessive loss of skeletal muscle mass in older adults with type 2 diabetes. Diabetes Care 2009;32:1993–1997.
24. Newman AB, Kupelian V, Visser M, et al. Sarcopenia: Alternative definitions and associations with lower extremity function. J Am Geriatr Soc 2003;51:1602–1609.

25. 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–M777.
26. Lau EM, Lynn HS, Woo JW, et al. Prevalence of and risk factors for sarcopenia in elderly Chinese men and women. J Gerontol A Biol Sci Med Sci 2005;60: 213–216.
27. Maggio M, Lauretani F, Ceda GP. Sex hormones and sarcopenia in older persons. Curr Opin Clin Nutr Metab Care 2013;16:3–13.
28. Auyeung TW, Lee JS, Kwok T, et al. Testosterone but not estradiol level is positively related to muscle strength and physical performance independent of muscle mass: A cross-sectional study in 1489 older men. Eur J Endocrinol 2011;164:811–817.
29. Dey DK, Bosaeus I, Lissner L, Steen B. Changes in body composition and its relation to muscle strength in 75-year-old men and women: A 5-year prospective follow-up study of the NORA cohort in Goteborg, Sweden. Nutrition 2009;25:613–619.
30. Auyeung TW, Lee JS, Leung J, et al. Adiposity to muscle ratio predicts incident physical limitation in a cohort of 3153 older adults-an alternative measurement of sarcopenia and sarcopenic obesity. Age (Dordr) 2013;35:1377–1385.
31. Chen CY. Meeting the challenges of eldercare in Taiwan's aging society. J Clin Gerontol Geriatr 2010;1:2–4.
32. Woo J. Meeting the needs of an ageing population in China: Public health and policy implications. J Clin Gerontol Geriatr 2013;4:31–32.
33. 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;39:412–423.
34. Morley JE. Sarcopenia: Diagnosis and treatment. J Nutr Health Aging 2008;12: 452–456.
35. 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; 12:249–256.
36. Lexell J, Taylor CC, Sjostrom M. What is the cause of the ageing atrophy? Total number, size and proportion of different fiber types studied in whole vastus lateralis muscle from 15- to 83-year-old men. J Neurol Sci 1988;84:275–294.
37. Frontera WR, Hughes VA, Fielding RA, et al. Aging of skeletal muscle: A 12-year longitudinal study. J Appl Physiol 2000;88:1321–1326.
38. Waters DL, Baumgartner RN, Garry PJ. Sarcopenia: Current perspectives. J Nutr Health Aging 2000;4:133–139.
39. 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;56:1710–1715.
40. Nigam P, Misra A, Colles SL. Comparison of DEXA-derived body fat measurement to two race-specific bioelectrical impedance equations in healthy Indians. Diabetes Metab Syndr 2013;7:72–77.
41. Mijnarends DM, Meijers JM, Halfens RJ, et al. Validity and reliability of tools to measure muscle mass, strength, and physical performance in community-dwelling older people: A systematic review. J Am Med Dir Assoc 2013;14: 170–178.
42. Janssen I, Heymsfield SB, Baumgartner RN, Ross R. Estimation of skeletal muscle mass by bioelectrical impedance analysis. J Appl Physiol 2000;89:465–471.
43. Yamada Y, Watanabe Y, Ikenaga M, et al. Comparison of single- or multi-frequency bioelectrical impedance analysis and spectroscopy for assessment of appendicular skeletal muscle in the elderly. J Appl Physiol 2013;115:812–818.
44. Kim M, Kim H. Accuracy of segmental multi-frequency bioelectrical impedance analysis for assessing whole-body and appendicular fat mass and lean soft tissue mass in frail women aged 75 years and older. Eur J Clin Nutr 2013;67:395–400.
45. Yeh CW, Chen YJ, Lai LY, et al. Bioelectrical impedance analysis in a mathematical model for estimating fat-free mass in multiple segments in elderly Taiwanese males. Int J Gerontol 2012;6:273–277.
46. Strasser EM, Draskovits T, Praschak M, et al. Association between ultrasound measurements of muscle thickness, pennation angle, echogenicity and skeletal muscle strength in the elderly. Age (Dordr) 2013;35:2377–2388.
47. Lee WJ, Liu LK, Peng LN, et al. Comparisons of sarcopenia defined by IWGS and EWGSOP criteria among older people: Results from the I-Lan longitudinal aging study. J Am Med Dir Assoc 2013;14:528.e1–528.e7.
48. Kim YS, Lee Y, Chung YS, et al. Prevalence of sarcopenia and sarcopenic obesity in the Korean population based on the Fourth Korean National Health and Nutritional Examination Surveys. J Gerontol A Biol Sci Med Sci 2012;67: 1107–1113.
49. Wu SW, Wu SF, Liang HW, et al. Measuring factors affecting grip strength in a Taiwan Chinese population and a comparison with consolidated norms. Appl Ergon 2009;40:811–815.
50. Liu LK, Lee WJ, Liu CL, et al. Age-related skeletal muscle mass loss and physical performance in Taiwan: Implications to diagnostic strategy of sarcopenia in Asia. Geriatr Gerontol Int 2013;13:964–971.
51. Functional outcomes for clinical trials in frail older persons. Time to be moving. J Gerontol A Biol Sci Med Sci 2008;63:160–164.
52. Guralnik JM, Ferrucci L, Pieper CF, et al. Lower extremity function and subsequent disability: Consistency across studies, predictive models, and value of gait speed alone compared with the short physical performance battery. J Gerontol A Biol Sci Med Sci 2000;55:M221–M231.
53. Cesari M, Kritchevsky SB, Newman AB, et al. Added value of physical performance measures in predicting adverse health-related events: Results from the Health, Aging And Body Composition Study. J Am Geriatr Soc 2009;57: 251–259.
54. Liu LK, Peng LN, Chen LY, et al. Timed Up-and-Go Test: A potential indicator for successful aging of older men in Taiwan. J Aging Res Clin Practice 2013;2: 152–156.
55. Chen L. Sarcopenia: Have we reached the consensus? J Frailty Aging 2012;1: 99–101.
56. Arango-Lopera VE, Arroyo P, Gutierrez-Robledo LM, et al. Mortality as an adverse outcome of sarcopenia. J Nutr Health Aging 2013;17:259–262.
57. Harber MP, Konopka AR, Douglass MD, et al. Aerobic exercise training improves whole muscle and single myofiber size and function in older women. Am J Physiol Regul Integr Comp Physiol 2009;297:R1452–R1459.
58. McCartney N, Hicks AL, Martin J, Webber CE. Long-term resistance training in the elderly: Effects on dynamic strength, exercise capacity, muscle, and bone. J Gerontol A Biol Sci Med Sci 1995;50:B97–B104.
59. Liu CJ, Latham NK. Progressive resistance strength training for improving physical function in older adults. Cochrane Database Syst Rev 2009;3: CD002759.
60. Farinatti PT, Geraldes AA, Bottaro MF, et al. Effects of different resistance training frequencies on the muscle strength and functional performance of active women older than 60 years. J Strength Cond Res 2013;27:2225–2234.
61. Liu-Ambrose T, Khan KM, Eng JJ, et al. Resistance and agility training reduce fall risk in women aged 75 to 85 with low bone mass: A 6-month randomized, controlled trial. J Am Geriatr Soc 2004;52:657–665.
62. Morley JE, Argiles JM, Evans WJ, et al. Nutritional recommendations for the management of sarcopenia. J Am Med Dir Assoc 2010;11:391–396.
63. Rudman D, Feller AG, Nagraj HS, et al. Effects of human growth hormone in men over 60 years old. N Engl J Med 1990;323:1–6.
64. Brill KT, Weltman AL, Gentili A, et al. Single and combined effects of growth hormone and testosterone administration on measures of body composition, physical performance, mood, sexual function, bone turnover, and muscle gene expression in healthy older men. J Clin Endocrinol Metab 2002;87:5649–5657.
65. Papadakis MA, Grady D, Black D, et al. Growth hormone replacement in healthy older men improves body composition but not functional ability. Ann Intern Med 1996;124:708–716.
66. Wallymahmed ME, Foy P, Shaw D, et al. Quality of life, body composition and muscle strength in adult growth hormone deficiency: The influence of growth hormone replacement therapy for up to 3 years. Clin Endocrinol 1997;47: 439–446.
67. Rodriguez-Arnao J, Jabbar A, Fulcher K, et al. Effects of growth hormone replacement on physical performance and body composition in GH deficient adults. Clin Endocrinol 1999;51:53–60.
68. Giannoulis MG, Martin FC, Nair KS, et al. Hormone replacement therapy and physical function in healthy older men. Time to talk hormones? Endocrine Rev 2012;33:314–377.
69. 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;110:57–65.
70. 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; 33:885–892.
71. Hwang B, Lim JY, Lee J, et al. Prevalence rate and associated factors of sarcopenic obesity in korean elderly population. J Korean Med Sci 2012;27: 748–755.
72. Pongchaiyakul C, Limpawattana P, Kotruchin P, Rajatanavin R. Prevalence of sarcopenia and associated factors among Thai population. J Bone Miner Metab 2013;31:346–350.
73. Manini TM, Visser M, Won-Park S, et al. Knee extension strength cutpoints for maintaining mobility. J Am Geriatr Soc 2007;55:451–457.
74. Kim KE, Jang SN, Lim S, et al. Relationship between muscle mass and physical performance: Is it the same in older adults with weak muscle strength? Age Ageing 2012;41:799–803.