HOSTED BY
ELSEVIER
CrossMark
Available online at www.sciencedirect.com
ScienceDirect
Osteoporosis and Sarcopenia 2 (2016) 110–115
http://www.elsevier.com/locate/afos

Original article

# The prevalence of sarcopenia and related factors in a community-dwelling elders Thai population

Nisakorn Khongsri [a], Sureeporn Tongsuntud [a], Patchara Limampai [b], Vilai Kuptniratsaikul [c,*]

[a] Division of Occupational Therapy, Department of Rehabilitation Medicine, Faculty of Medicine Siriraj Hospital, Mahidol University, 2 Prannok Road, Bangkok-Noi, Bangkok, 10700, Thailand
[b] Division of Rehabilitation Psychology and Recreation, Department of Rehabilitation Medicine, Faculty of Medicine Siriraj Hospital, Mahidol University, 2 Prannok Road, Bangkok-Noi, Bangkok, 10700, Thailand
[c] Department of Rehabilitation Medicine, Faculty of Medicine Siriraj Hospital, Mahidol University, 2 Prannok Road, Bangkok-Noi, Bangkok, 10700, Thailand

Received 1 March 2016; revised 11 April 2016; accepted 2 May 2016
Available online 1 June 2016

## Abstract

*Background*: Sarcopenia is one of common problems among elderly worldwide.
*Objectives*: Sarcopenia is one of common problems among elderly worldwide. To determine the prevalence of sarcopenia and related factors in community-dwelling elders Thai population.
*Methods*: This cross-sectional study was performed in 243 subjects aged over 60 years. All participants were evaluated for handgrip strength by dynamometer and for gait speed by walking a 6-m distance. The muscle mass for subjects who had abnormal grip strength and/or gait speed was evaluated by bioimpedance analysis (BIA). The prevalence of sarcopenia was calculated and factors related to sarcopenia were also analyzed.
*Results*: The mean age was 69.7 ± 6.9 years with three-fourths female participants. Approximate 60% of subjects were overweight. There were 74 participants (30.5%, (95% CI: 25.0%–36.5%)) with abnormal grip strength; gait speed and muscle mass. Males had more prevalence than females (33.9% vs. 29.3% respectively). There is higher prevalence with increasing age among both genders (17.9%, 41.4% and 80.0% in young old, middle old, and the very old groups respectively in male; and 11.5%, 49.1%, and 65.0% in female). After using multivariate analysis, age, body mass index (BMI), and quadriceps strengths were significantly related to sarcopenia with the adjusted odds ratio of 15.47 (95% CI: 4.93, 48.54), 12.84 (95% CI: 3.85, 42.82) and 3.77 (95% CI: 1.70, 8.37) respectively.
*Conclusions*: Thirty percent of the community-based elderly experienced sarcopenia. As the prevalence is high, the screening for sarcopenia should be performed in community-dwelling elders especially older age, underweight subjects and lower quadriceps strength.


*Keywords:* Sarcopenia; Prevalence; Community-dwelling elders; Factors

## 1. Introduction

Sarcopenia is a disease of progressive loss of muscle mass and associated with a decrease in muscle strength as well as physical performance [1]. The International Working Group on Sarcopenia proposed definition of sarcopenia in 2009 as "age-associated loss of skeletal muscle mass and functions which were strength and performance as well" [2]. Nowadays, sarcopenia becomes public interest and is recognized worldwide. Its consequences greatly impact on muscle performance, functional decline, physical disability, poor quality of life and even death in some patients. It can affect the ability to maintain an active lifestyle and associate with mobility limitation [3].

Furthermore, the healthcare costs for sarcopenia is high. Janssen and colleagues reported the estimated direct

* Corresponding author. Department of Rehabilitation Medicine, Faculty of Medicine Siriraj Hospital, Mahidol University, 2 Prannok Road, Bangkok-Noi, Bangkok, 10700, Thailand.
*E-mail addresses:* nisakorn.khong@gmail.com (N. Khongsri), sureeporn9194@gmail.com (S. Tongsuntud), panuspatampai@gmail.com (P. Limampai), vilai.kup@mahidol.ac.th (V. Kuptniratsaikul).
Peer review under responsibility of The Korean Society of Osteoporosis.

http://dx.doi.org/10.1016/j.afos.2016.05.001

healthcare cost of sarcopenia of $18.5 billion in US in the year 2000 (1.5% of total healthcare expenditure) [4], the healthcare cost was in excess of $860–933 for every client with sarcopenia. A 10% reduction in the prevalence of sarcopenia can save $1.1 billion dollars per year. This represents very high healthcare costs in USA. As sarcopenia is commonly found in elderly with advancing age, prevalence of sarcopenia is an important societal and public health concern.

Many studies reported the prevalence of sarcopenia which varied in method, criteria or type of elderly. Cruz-Jentoft and colleagues performed asystemic review published in 2014 on the prevalence on sarcopenia which ranged from 1 to 29% of the older adults living in the community [5]. In addition, this number increased to 14–33% for the long-term care older residents [6,7]. In rehabilitation setting, the prevalence was higher up to 60% among elder patients admitted in rehabilitation ward [8].

Besides from the prevalence of sarcopenia, factors related to it were also crucial. Concerning to those factors, some studies reported age, gender and level of physical activities as factors related to sarcopenia [9,10]. Beasley et al. mentioned the risk factors for sarcopenia as age, malnutrition and physical inactivity [11]. Furthermore, some believed its causes were from multiple factors including disuse, malnutrition, age-related cellular changes, apoptosis, and genetic predisposition as presented by Hida and colleagues [12]. Walston JD also reported multiple factors such as neurological decline, hormonal changes, inflammatory pathway activation, declines in activity, chronic illness, fatty infiltration, and poor nutrition served as contributing factors to sarcopenia [3].

As sarcopenia is one of the major health problems in aging, the current study objectives were to investigate the prevalence of sarcopenia in community-dwelling Thai elders and related factors.

## 2. Methods

This study has a cross-sectional design. In April 2015, personnel from Department of Rehabilitation Medicine, Faculty of Medicine Siriraj Hospital performed corporeal social responsibility (CSR) activity in Ampawa Province, Samutsongkram, in central Thailand. “CSR” means any activities that an organization performs for the sake of humanity with respect to society. Staff in our department volunteered to create health activity among community-residing elderly aged more than 60 years. Our activities were to investigate health status and giving health education about the common musculoskeletal diseases in elderly including sarcopenia, osteoarthritis, osteoporosis, and fall prevention. To avoid selection bias, all participants were elderly who could walk and join our activity at the city hall of Ampawa Province. This study was approved by the Ethical Review committee of the Faculty of Medicine, Siriraj Hospital.

Demographic data including age, sex, body weight, height, and underlying diseases were recorded. Those underlying diseases were diagnosed by their primary doctor. Fall frequency was assessed by asking participants with the sentence “Have you ever had a fall (or falls) this year?” In addition, the body mass index was calculated from weight/height (meter)$^2$ and was categorized into 3 groups: underweight (BMI < 18.5 kg/m$^2$), normal (BMI = 18.5–23.0 kg/m$^2$) and overweight (BMI > 23.0 kg/m$^2$) [13]. To investigate health status, the quadriceps strength of dominant leg was measured twice in a sitting position by using hand-held dynamometer, Lafayette Manual Muscle Test System (MMT)® model 01163 (Lafayette Instruments, Lafayette, IN, USA). The maximal value was selected. The cut-off value for quadriceps strength in male and female were 18.0 and 16.0 kg respectively [14].

For assessment of physical performance, grip strength and gait speed were evaluated. Grip strength was measured by using hand-held dynamometer (Jamar hand dynamometer, Preston Jackson, Michigan, 49203, USA). Participants sit upright, adducted arms beside trunk and flexed elbows 90°. They were asked to hold hand dynamometer tightly and squeezed as strongly as they could. They were allowed to practice once before testing. Then, the grip strength was tested in dominant hand twice, and the maximal value was selected. The cut-off values in male and female were 26 kg and 18 kg respectively [15]. The gait speed was evaluated by asking participants to walk 10-m distance. Time was recorded from the2-meter to 8-m marker. Then, the gait speed was calculated from time using in 6-m walk with the cut-off value of 0.8 m/s [16].

Participants who had abnormal handgrip strength and/or gait speed were evaluated for lean body mass by using Bio-impedance Analyzer Model 450 (Biodynamics, Seattle, WA, USA). We calculated lean body mass from percentage of whole body skeletal mass multiplied by body weight, and divided by 100. The one who had lean body mass less than 7 kg/m$^2$ in male or 5.7 kg/m$^2$ in female were considered abnormal muscle mass [15]. Then, the prevalence of sarcopenia was calculated. In addition, the prevalence categorized by different gender, different age groups (young old: 60–69 years; middle old: 70–79 years; the very old: ≥80 years) and among different gender and different age groups, were done. The factors related to sarcopenia were analyzed including age, sex, body mass index (BMI), history of falls and quadriceps strength.

### 2.1. Statistical analysis

The continuous data was presented as mean ± standard deviation (SD). The categorical data was presented as number (n) and percentage (%). Univariate factors related to sarcopenia were analyzed using chi-square test. Multiple logistic regression was used to adjust for confounding for multivariate analysis. The strength of association was measured using odds ratio (OR) with 95% confidence intervals (95% CI). The p-value of <0.05 was considered statistically significant. Data analysis was performed with PASW Statistics (SPSS) 18.0 (SPSS Inc., Chicago, IL, USA).

## 3. Results

The total number was 243 elder participants with a mean (SD) of 69.7 (6.9) years. Three-fourths of participants were

Table 1
Demographic data of all study participants.

| Demographic data | n = 243 |
|---|---|
| Age (y) | 69.7 ± 6.9 |
| Age (y) | |
| 60–69 | 132 (54.3) |
| 70–79 | 86 (35.4) |
| ≥80 | 25 (10.3) |
| Sex | |
| Male | 62 (25.5) |
| Female | 181 (74.5) |
| Body mass index | |
| Underweight (<18.5 kg/m$^2$) | 21 (8.6) |
| Normal (18.5–23.0 kg/m$^2$) | 77 (31.7) |
| Overweight (>23.0 kg/m$^2$) | 145 (59.7) |
| Underlying diseases | |
| Diabetes mellitus | 47 (19.3) |
| Hypertension | 134 (55.1) |
| Hyperlipidemia | 89 (36.6) |
| Knee osteoarthritis | 88 (36.2) |
| Back pain | 107 (44.0) |
| Fragility fracture from fall | 12 (4.9) |

Data are presented as mean ± standard deviation or n (%).

female and approximately 60% of subjects were overweight. The common underlying diseases were hypertension (55.1%), back pain (44.0%), hyperlipidemia (36.6%), knee osteoarthritis (36.2%) and diabetes mellitus (19.3%) (Table 1). Table 2 presents mean and SD of grip strength, gait speed and muscle mass categorized by cut-point values and gender. Males had significantly higher values than females in all variables except in abnormal gait speed among male and female groups. (p = 0.504).

Fig. 1 shows diagram of screening for sarcopenia in 243 community-based elderly. Seventy-eight subjects (32.1%) had abnormal gait speed and 49 (20.2%) had abnormal grip strength. Then, 127 participants with abnormal gait and grip strength were evaluated for BIA. After performing BIA, only 74 subjects had muscle mass below cutoff value. Therefore, the prevalence of sarcopenia was 30.5% (74 from 243) (95% CI: 25.0%–36.5%). Fig. 2 presents the prevalence of sarcopenia among different gender. Male has more prevalent than female (33.9% vs. 29.3% respectively). Concerning age, there is increasing trend when participants get older (12.9% in young old, 46.5% in middle old, and 68.0% in the very old groups) (Fig. 3). Fig. 4 presents prevalence of sarcopenia among different gender and different age groups. Our results show increasing trend with increasing age among both gender (17.9%, 41.4% and 80.0% in young old, middle old, and the very old groups respectively in male; and 11.5%, 49.1%, and 65.0% in female).

Table 3 shows factors related to sarcopenia using univariate and multivariate analysis including age, sex, BMI, history of fall and quadriceps strength. After adjusted for multiple factors, only age, BMI, and quadriceps strength were significantly related to sarcopenia with the adjusted odds ratio of 15.47 (95% CI: 4.93, 48.54), 12.84 (95% CI: 3.85, 42.82) and 3.77 (95% CI: 1.70, 8.37) respectively.

## 4. Discussion

The European Working Group on Sarcopenia in Older People (EWGSOP) defined term of sarcopenia as 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 [5]. As sarcopenia had an impact on health and quality of life, the study of prevalence provides information to guide direction of health care services in our country. The prevalence of sarcopenia in this study was 30.5% with male preference than female (33.9% vs. 29.3%). This prevalence was in line with the study of Landi et al. who reported that sarcopenia seemed to be related with gender; especially more commonly occurred in males than female (68% vs. 21%), but their study was performed among nursing home older residents [6]. In the following year, Landi et al. did a study in the community-dwelling elders and reported the prevalence of 29.1% with more prevalence in female than in male (30.1% vs. 27.1%) [17]. However, they measured muscle mass by using mid-arm muscle circumference technique which was different from our study.

A study from China reported the prevalence of sarcopenia in community-dwelling of 9.8% (12.0% for female and 6.7% for male). It also presents higher prevalence in rural elders than in urban elders (13.1% vs. 7.0%) [18]. Another study

Table 2
Grip strength, gait speed, and muscle mass of all participants and participants categorized by sex.

| Para-meters | Groups | Cut-off values | *n* | Total | Male | Female | p |
|---|---|---|---|---|---|---|---|
| Grip strength | Normal | M >26 kg<br>F >18 kg | 154 | 25.2 ± 6.2 | 34.2 ± 5.0 | 22.9 ± 3.8 | <0.001 |
| | Abnormal | M ≤26 kg<br>F ≤18 kg | 89 | 16.8 ± 4.7 | 21.2 ± 4.6 | 14.6 ± 2.8 | <0.001 |
| Gait speed | Normal | >0.8 m/s | 165 | 1.00 ± 0.16 | 1.07 ± 0.20 | 0.98 ± 0.13 | 0.005 |
| | Abnormal | ≤0.8 m/s | 78 | 0.65 ± 0.12 | 0.67 ± 0.10 | 0.65 ± 0.12 | 0.504 |
| Muscle mass | Normal | M >7.0 kg/m$^2$<br>F >5.7 kg/m$^2$ | 53 | 6.9 ± 1.3 | 8.3 ± 1.6 | 6.5 ± 0.8 | 0.012 |
| | Abnormal | M ≤7.0 kg/m$^2$<br>F ≤5.7 kg/m$^2$ | 74 | 5.1 ± 0.8 | 5.7 ± 0.8 | 4.8 ± 0.6 | <0.001 |

Data are presented as mean ± standard deviation unless otherwise indicated.
M, male; F, female.

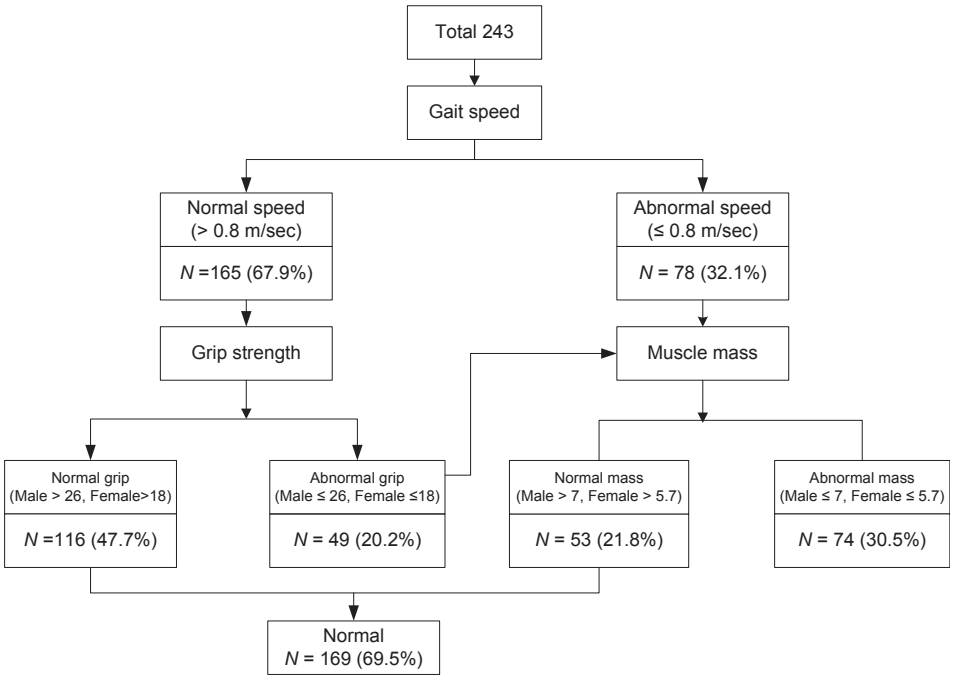


Fig. 1. Diagram of screening for sarcopenia in older community-based participants.

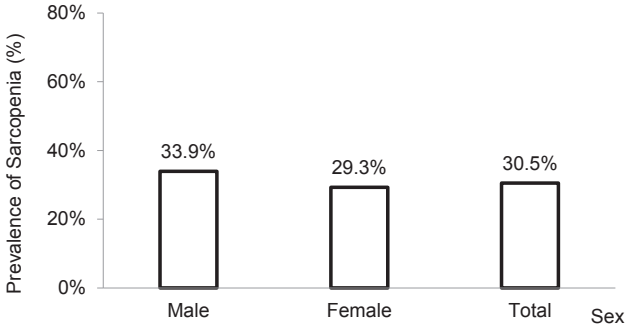


Fig. 2. Prevalence of sarcopenia between different sexes.

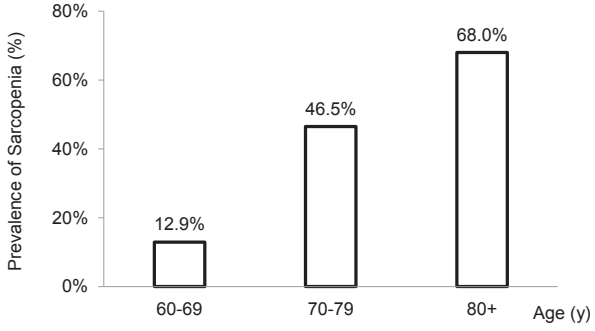


Fig. 3. Prevalence of sarcopenia among different age groups.

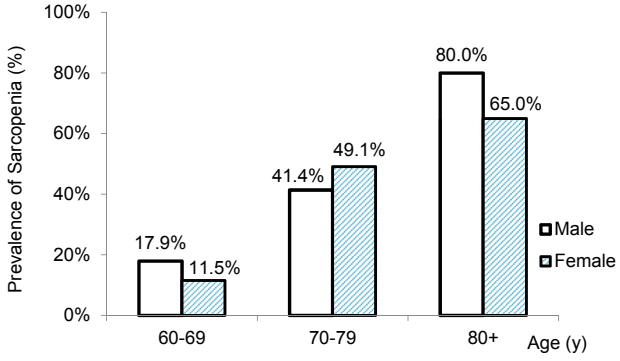


Fig. 4. Prevalence of sarcopenia between different sexes and among different age groups.

from Germany which was performed in community-dwelling women aged 70 years and older, presents the prevalence of 4.5% (2.8% in age 70–79 years vs. 9.9% in age ≥80 years) [19] which was lower than ours. This may be because they used lower cut-off value (normal grip ≥20 kg, normal muscle mass >5.66 kg/m$^2$) compared to ours (normal grip in male >26, and in female >18 kg; normal muscle mass in male >7 kg/m$^2$, and in female >5.7 kg/m$^2$), so the number of abnormal participants was less than our study. There are two studies from Japan which reported the prevalence of sarcopenia using BIA for measurement of muscle mass of 10.7%–22.1% [20,21]. The prevalence in our study was higher than the other studies from Asian countries. This may come from different cut-off value. This issue should be concerned to use standardized cut-off value, therefore, we can compare the results among countries.

Pongchaiyakul and colleagues reported the prevalence of sarcopenia in the Thai population using the skeletal muscle index (SMI) criteria [22]. They found the prevalence among men and women was 35.33% (95% CI: 29.91, 40.41) and 34.74% (95% CI: 30.56, 39.10) respectively, which was close to our results. In addition, they also found three factors

Table 3
Factors related to sarcopenia in univariate and multivariate analyses.

| Factors | Sarcopenia | | Crude odds ratio (95% CI)[a] | Adjusted odds ratio (95% CI)[b] |
|---|---|---|---|---|
| | Yes (n = 74) | No (n = 169) | | |
| Age (y) | | | | |
| ≥60–69 | 17 (23.0) | 115 (68.0) | 1.00 | 1.00 |
| ≥70–79 | 40 (54.1) | 46 (27.2) | 5.88 (3.03–11.41)[c] | 6.19 (2.91–13.18)[c] |
| ≥80 | 17 (23.0) | 8 (4.7) | 14.37 (5.38–38.40)[c] | 15.47 (4.93–48.54)[c] |
| Sex | | | | |
| Male | 21 (28.4) | 41 (24.3) | 1.00 | – |
| Female | 53 (71.6) | 128 (75.7) | 0.81 (0.44–1.50) | |
| Body mass index | | | | |
| >23.0 kg/m$^2$ | 24 (32.4) | 121 (71.6) | 1.00 | 1.00 |
| 18.5–23.0 kg/m$^2$ | 36 (48.7) | 41 (24.3) | 4.43 (2.37–8.28)[c] | 4.70 (2.23–9.92)[c] |
| <18.5 kg/m$^2$ | 14 (18.9) | 7 (4.1) | 10.08 (3.68–27.62)[c] | 12.84 (3.85–42.82)[c] |
| History of falls | | | | |
| 0–1 | 61 (83.6) | 148 (88.1) | 1.00 | – |
| ≥2 | 12 (16.4) | 20 (11.9) | 1.46 (0.67–3.16) | |
| Quadriceps strength[d] | | | | |
| Normal | 43 (60.6) | 138 (84.1) | 1.00 | 1.00 |
| Abnormal | 28 (39.4) | 26 (15.9) | 3.46 (1.83–6.52)[c] | 3.77 (1.70–8.37)[c] |

Data are presented as n (%) unless otherwise indicated.
CI, confidence interval.
[a] Chi-square test.
[b] Multiple logistic regression.
[c] Statistically significant.
[d] Normal quadriceps strength: >18 kg in males and >16 kg in females.

associated with sarcopenia which were living in the urban area, higher BMI, and older age. Their results confirmed that sarcopenia increases with age. Most studies in the systematic review suggested that the prevalence of sarcopenia increased with age [5]. Our results also presented increasing trend according to age, both in male and female. This may due to loss of muscle mass when they aged. There were evidences concerning progressive loss of muscle mass after age of 60 years and accelerating after age of 75 years [23,24].

Concerning the factors related to sarcopenia, we found that older age, low BMI and low quadriceps strength were associated with sarcopenia. This was in line with the other studies [25–28]. For example, Senior et al. performed study in nursing home elderly and reported that only BMI is a predictive factor for sarcopenia (OR 0.8; 95% CI: 0.65, 0.97) [25]. In addition, Yalcin et al. also found that BMI and calf circumference were associated with sarcopenia [26]. Older age was another important factors as presented by Martinez et al. (OR 1.14; 95% CI: 1.06, 1.23) [27]. Han et al. also reported the factors related to sarcopenia as older age for both genders and inversely associated with BMI for both genders as well [28]. Furthermore, Santilli and colleague reported risk factors for sarcopenia including age, gender and level of physical activity. Elders with low physical activity or inactivity, loss of their muscle mass and also strength [9]. Therefore, they suggested aging to be physically active which could be a protective factor for sarcopenia.

One of the major components of sarcopenia was age-related decline in muscle mass. It can cause mobility limitations, functional decline, disability and dependency. Not only changes in muscle mass but also muscle quality occurred with aging [29]. Our result found that quadriceps strength was one of factors related to sarcopenia. This may be explained that quadriceps strength play a major role for walking and balancing which represent physical performance especially gait speed in elderly [30,31]. de Oliveira and colleague examined the association between quadriceps strength and sarcopenia with aerobic fitness indexes in 189 elderly women. They reported that elderly with sarcopenia presented significantly lower muscle strength and $VO_2$ peak when compared to non-sarcopenic patients [32]. Therefore, quadriceps-strengthening exercises should be emphasized to improve functions of lower extremities in sarcopenia. Finally, our study could not find any novel risk factors, therefore we confirm that older age, low BMI and low quadriceps strength are important clinical risk factors.

There were some limitations of this study including selection bias as all participants were elders who could walk and join our activity at the City Hall of Ampawa Province. In addition, the machine used to measure muscle mass was portable BIA which could not measure appendicular weight, therefore we used whole body muscle mass instead of limb mass. Furthermore, the generalizability of the findings had some limitation because we recruited subjects at only one community which may not be directly representative of Thai elderly. More studies that recruit elderly from the other parts including northern, north-eastern, central and southern parts of Thailand, should be performed.

## 5. Conclusion

The prevalence of sarcopenia in community-dwelling elders in Thailand was quite high (approximately one-third). Factors related to sarcopenia were age, BMI and

quadriceps strength. Resistive exercise for improving quadriceps strength should be emphasized to improve functions of lower extremities in sarcopenia.

## Authorship

NK, ST, and PL contributed in data acquisition, analysis and interpretation of data, revision of the manuscript and final approval of the version. VK created the conception and design of the study, analysis and interpretation of data, drafting the article, revising the manuscript and final approval of the version.

## Conflicts of interest

There is no conflict of interest.

## Acknowledgements

Authors would like to thank all staff of Rehabilitation Medicine Department, Faculty of Medicine Siriraj Hospital, Mahidol University for joining in the corporeal social responsibility of our department. We also thank Miss Julaporn Poolium for statistical analysis and Miss Supin Sarika for manuscript preparation.

## References

[1] Morley JE, Baumgartner RN, Roubenoff R, Mayer J, Nair KS. Sarcopenia. J Lab Clin Med 2001;137:231–43.
[2] Fielding RA, Vellas B, Evans WJ, Bhasin S, Morley JE, Newman AB, 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.
[3] Walston JD. Sarcopenia in older adults. Curr Opin Rheumatol 2012;24:623–7.
[4] Janssen I, Shepard DS, Katzmarzyk PT, Roubenoff R. The healthcare costs of sarcopenia in the United States. J Am Geriatr Soc 2004;52:80–5.
[5] Cruz-Jentoft AJ, Landi F, Schneider SM, Zúñiga C, Arai H, Boirie Y, et al. Prevalence of and interventions for sarcopenia in ageing adults: a systematic review. Report of the International Sarcopenia Initiative (EWGSOP and IWGS). Age Ageing 2014;43:748–59.
[6] Landi F, Liperoti R, Fusco D, Mastropaolo S, Quattrociocchi D, Proia A, et al. Prevalence and risk factors of sarcopenia among nursing home older residents. J Gerontol A Biol Sci Med Sci 2012;67:48–55.
[7] Bastiaanse LP, Hilgenkamp TI, Echteld MA, Evenhuis HM. Prevalence and associated factors of sarcopenia in older adults with intellectual disabilities. Res Dev Disabil 2012;33:2004–12.
[8] Morandi A, Onder G, Fodri L, Sanniti A, Schnelle J, Simmons S, et al. The association between the probability of sarcopenia and functional outcomes in older patients undergoing in-hospital rehabilitation. J Am Med Dir Assoc 2015;16:951–6.
[9] Santilli V, Bernetti A, Mangone M, Paoloni M. Clinical definition of sarcopenia. Clin Cases Miner Bone Metab 2014;11:177–80.
[10] Sayer AA, Robinson SM, Patel HP, Shavlakadze T, Cooper C, Grounds MD. New horizons in the pathogenesis, diagnosis and management of sarcopenia. Age Ageing 2013;42:145–50.
[11] Beasley JM, Shikany JM, Thomson CA. The role of dietary protein intake in the prevention of sarcopenia of aging. Nutr Clin Pract 2013;28:684–90.
[12] Hida T, Harada A, Imagama S, Ishiguro N. Managing sarcopenia and its related-fractures to improve quality of life in geriatric populations. Aging Dis 2013;5:226–37.
[13] WHO Expert Consultation. Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. Lancet 2004;363:157–63.
[14] Assantachai P, Muangpaisan W, Intalapaporn S, Sitthichai K, Udompunturak S. Cut-off points of quadriceps strength, declines and relationships of sarcopenia-related variables among Thai community-dwelling older adults. Geriatr Gerontol Int 2014;14(Suppl. 1):61–8.
[15] Chen LK, Liu LK, Woo J, Assantachai P, Auyeung TW, Bahyah KS, et al. Sarcopenia in Asia: consensus report of the Asian Working Group for Sarcopenia. J Am Med Dir Assoc 2014;15:95–101.
[16] Cruz-Jentoft AJ, Baeyens JP, Bauer JM, Boirie Y, Cederholm T, Landi F, 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.
[17] Landi F, Liperoti R, Russo A, Giovannini S, Tosato M, Barillaro C, et al. Association of anorexia with sarcopenia in a community-dwelling elderly population: results from the ilSIRENTE study. Eur J Nutr 2013;52:1261–8.
[18] Gao L, Jiang J, Yang M, Hao Q, Luo L, Dong B. Prevalence of sarcopenia and associated factors in Chinese community-dwelling elderly: comparison between rural and urban areas. J Am Med Dir Assoc 2015;16:1003.e1–6. http://dx.doi.org/10.1016/j.jamda.2015.07.020. Epub 2015 Sep 15.
[19] Kemmler W, Teschler M, Goisser S, Bebenek M, von Stengel S, Bollheimer LC, et al. Prevalence of sarcopenia in Germany and the corresponding effect of osteoarthritis in females 70 years and older living in the community: results of the FORMoSA study. Clin Interv Aging 2015;10:1565–73.
[20] Tanimoto Y, Watanabe M, Sun W, Sugiura Y, Hayashida I, Kusabiraki T, et al. Sarcopenia and falls in community-dwelling elderly subjects in Japan: defining sarcopenia according to criteria of the European Working Group on Sarcopenia in Older People. Arch Gerontol Geriatr 2014;59:295–9.
[21] Yamada M, Nishiguchi S, Fukutani N, Tanigawa T, Yukutake T, Kayama H, et al. Prevalence of sarcopenia in community-dwelling Japanese older adults. J Am Med Dir Assoc 2013;14:911–5.
[22] Pongchaiyakul C, Limpawattana P, Kotruchin P, Rajatanavin R. Prevalence of sarcopenia and associated factors among Thai population. J Bone Miner Metab 2013;31:346–50.
[23] Frontera WR, Zayas AR, Rodriguez N. Aging of human muscle: understanding sarcopenia at the single muscle cell level. Phys Med Rehabil Clin N Am 2012;23:201–7.
[24] Waters DL, Baumgartner RN, Garry PJ. Sarcopenia: current perspectives. J Nutr Health Aging 2000;4:133–9.
[25] Senior HE, Henwood TR, Beller EM, Mitchell GK, Keogh JW. Prevalence and risk factors of sarcopenia among adults living in nursing homes. Maturitas 2015;82:418–23.
[26] Yalcin A, Aras S, Atmis V, Cengiz OK, Varli M, Cinar E, et al. Sarcopenia prevalence and factors associated with sarcopenia in older people living in a nursing home in Ankara Turkey. Geriatr Gerontol Int 2015 Aug 5. http://dx.doi.org/10.1111/ggi.12570 [Epub ahead of print].
[27] Martinez BP, Batista AK, Gomes IB, Olivieri FM, Camelier FW, Camelier AA. Frequency of sarcopenia and associated factors among hospitalized elderly patients. BMC Musculoskelet Disord 2015;16:108–14.
[28] Han P, Kang L, Guo Q, Wang J, Zhang W, Shen S, et al. Prevalence and factors associated with sarcopenia in suburb-dwelling older Chinese using the Asian Working Group for Sarcopenia definition. J Gerontol A Biol Sci Med Sci 2016;71:529–35. pii: glv108. [Epub ahead of print].
[29] McGregor RA, Cameron-Smith D, Poppitt SD. It is not just muscle mass: a review of muscle quality, composition and metabolism during ageing as determinants of muscle function and mobility in later life. Longev Heal 2014;3:9–16.
[30] Carter ND, Khan KM, Mallinson A, Janssen PA, Heinonen A, Petit MA, et al. Knee extension strength is a significant determinant of static and dynamic balance as well as quality of life in older community-dwelling women with osteoporosis. Gerontology 2002;48:360–8.
[31] Segal NA, Glass NA. Is quadriceps muscle weakness a risk factor for incident or progressive knee osteoarthritis? Phys Sportsmed 2011;39:44–50.
[32] de Oliveira RJ, Bottaro M, Motta AM, Pitanga F, Guido M, Leite TK, et al. Association between sarcopenia-related phenotypes and aerobic capacity indexes of older women. J Sports Sci Med 2009;8:337–43.