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Original article

Comparison of lower leg muscle strength and grip strength for diagnosing slower gait speed in the elderly

Junko Ohta [a], Momoyo Seki [b], Misora Ao [b], Rina Okajima [b], Akiko Kuwabara [c], Hiroko Takaoka [d], Kaoru Aoyama [d], Kiyoshi Tanaka [b, *]

[a] Faculty of Nutrition, Kobegakuin University, Kobe, Japan
[b] Department of Food and Nutrition, Kyoto Women's University, Kyoto, Japan
[c] Department of Health and Nutrition, Osaka Shoin Women's University, Higashiosaka, Japan
[d] Nursing Care Home, Life in Kyoto, Kyoto, Japan

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ABSTRACT

Objectives: Sarcopenia, decreased muscle volume and muscle weakness in the elderly is a serious risk of various adverse outcomes. Current diagnostic procedure for sarcopenia includes gait speed, grip strength, and percentage of skeletal muscle volume. However, lower leg muscle strength decreases much faster than grasp power, and we have evaluated the usefulness of its measurement using a recently developed instrument (Locomoscan).
Methods: Forty-three institutionalized elderly subjects were evaluated for their anthropometrical parameters, body composition, grasp and lower leg muscle strength, and gait speed. They were categorized into 2 groups; gait speed equal to or higher than 0.8 m/s and that below 0.8 m/s.
Results: Leg muscle strength per body weight was significantly greater in those with their gait speed equal to or higher than 0.8 m/s, whereas there was no significant difference in other parameters. Receiver operator characteristics analysis has shown that leg muscle alone significantly predicted the greater gait speed.
Conclusions: Lower leg muscle strength can be useful for predicting gait speed.

1. Introduction

Japan has become a rapidly aging society. The percentage of subjects aged 65 and over is now as high as 25.1% of the Japanese population in 2014 [1]. Life expectancy is 80.50 years for men, and 86.83 years for women [2]. However, healthy life expectancy is much shorter than these values; 70.42 years for men and 73.62 years for women [3], and the difference between life expectancy and healthy life expectancy is 10.08 years for men and 13.21 years for women. Elderly subjects are likely to spend these years in the diseased states and at higher risk of being in need of care, which is a great burden to the individual and also to the society. Number of persons requiring long-term care has increased by 1.23 times between 2000 and 2014 [4].

The leading underlying diseases in need for nursing care are cerebrovascular disease (18.5%), dementia (15.8%), and frailty (13.4%) as a whole. In contrast, musculoskeletal diseases constitute the major underlying causes for light care; joint disease (20.7%), frailty (15.4%), and falling and fracture (14.6%) [5]. Elderly subjects requiring light care is quite likely to have shortened healthy life expectancy, even though the biological life expectancy is not much affected. Thus, prevention of the musculoskeletal disorders is essential for the health promotion of the elderly.

Sarcopenia refers to a state with progressive and generalized loss of skeletal muscle mass and strength, resulting in a higher risk of various adverse outcomes such as physical disability, impaired quality of life and even higher mortality [6,7]. A diagnostic guideline for sarcopenia was published by European Working Group on Sarcopenia in Older People (EWGSOP), which was adopted by Japan Geriatric Society. In brief, subjects are first screened into those with gait speed equal to or higher than 0.8 m/s and those below it. They are further categorized based on the grip strength and percentage of skeletal muscle volume [6].

* Corresponding author. Department of Food and Nutrition, Kyoto Women's University, 35, Imakumano-kitahiyoshicho, Higashiyama, 605-8501, Kyoto, Japan.
E-mail address: ktanaka@kyoto-wu.ac.jp (K. Tanaka).
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Two issues were our concern regarding this diagnostic protocol. First one is the validity to evaluate sarcopenia by the muscle mass. Muscle mass can be measured by various methods such as computed tomography, magnetic resonance imaging, dual energy X-ray absorptiometry, and also by bioelectrical impedance analysis (BIA) for the screening purpose. All these instruments yield data on muscle mass, but not muscle strength. Unlike in the youth, muscle strength is not necessarily proportional to muscle mass in the elderly due to involutional changes such as increased intramuscular adipocity [7]. Second one is the validity to employ grip strength. Since, age-related decline of muscle strength is more prominent in lower extremity than in the upper extremity [8], grip strength may not be ideal in the diagnosis of sarcopenia. Nevertheless, grip strength has been most frequently used, probably because of its ease and availability. Recently, however, a novel instrument was developed (Locomoscan, Alcare Co. Ltd., Tokyo, Japan) to easily measure quadriceps strength as will be detailed in "Methods" section [9,10]. Based on these considerations, we have studied the usefulness of leg muscle strength to predict the gait speed which was employed as one of the representative indicators of activity of daily living (ADL).

Based on these considerations, we have considered it worthwhile to compare the usefulness of grip strength and lower leg muscle strength measurement for predicting gait speed, a key component of sarcopenia.

2. Methods

2.1. Subjects

The study subjects were 43 (11 male and 32 female subjects) elderly nursing home residents in a nursing home in Kyoto. They were informed of the study protocol, and written informed consent was obtained. The study protocol was done conforming to the Declaration of Helsinki, and approved by the Ethical Committee in Kyoto Women's University (approval number: 25-20). Written informed consent was obtained from each participant. Subjects with conditions which make the muscle strength measurement difficult such as deformity or paralysis in their extremity were excluded. Those with dementia were also excluded.

2.2. Anthropometric and body composition measurement

Height was measured using stadiometer (Seca213, Yagami Inc., Nagoya, Japan). Body weight and body composition was measured with BIA equipment (Karada Scan; Omron HealthCare, Co. Ltd., Kyoto, Japan). Body mass index (BMI) was calculated as body weight (kg) divided by squared height (m).

2.3. Measurement of muscle strength

Measurement of muscle strength was done for grip and leg. Grip strength was evaluated according to The Japan Fitness Test. In brief, measurement was performed in an upright position using a hand dynamometer (T.K.K5401, Digital Grip Dynamometer, Takei Scientific Instruments, Niigata, Japan). Leg muscle strength was evaluated using Locomoscan (AllCare Co. Ltd., Tokyo, Japan), which is a recently developed instrument mainly reflecting the quadriceps strength. Subjects lie on a table with one of their legs stretched, push down a pillow located beneath their knee. Then a sensor in the pillow detects the power loaded on it, which mainly represent the quadriceps strength. It is characterized by its easiness to perform, freedom from pain, and short duration of time required [9,10]. Additionally, muscle strength measured by Locomoscan has reported to be well correlated with that by Biodex ($r = 0.82$), which is a far larger standard instrument with known accuracy [9]. The results are expressed in kilogram for grip strength and in Newton for leg muscle strength.

2.4. Measurement of gait speed

Gait speed was measured in accordance with the instruction in Short Physical Performance Battery [11]. In brief, subjects were asked to walk at their usual speed for 4 m. First, they stand with both feet touching the starting line, walk all the way past the other end of the tape before stop. Gait speed was defined as distance (4 m) divided by the time between the subjects begin walking and when one of the participants' feet is completely across the end line. Results were expressed as the gait speed (m/s).

2.5. Statistical analysis

Statistical analysis was done with IBM SPSS Statistics ver. 22.0 (IBM Co., Armonk, NY, USA). Comparison of 2 independent variables was done with Student t-test. Correlation of 2 variables was done with Pearson correlation coefficient. The predictive value of various parameters for gait speed was analyzed by receiver operating characteristic (ROC) curve, the details of which will be described below. Statistical significance was defined as $P < 0.05$.

3. Results

Background profiles of the study subjects are shown in Table 1. They were aged 82.9 years as the average with no gender difference. Although men had higher height and weight, BMI was no different. Percentage of fat was lower and that of skeletal mass was higher in men.

According to the diagnostic protocol for sarcopenia by EWGSOP, subjects were categorized into 2 groups; gait speed equal to or greater than 0.8 m/s and that less than 0.8 m/s. As shown in Table 2, leg muscle strength per body weight (N/kg) was significantly greater in those with gait speed equal to or greater than 0.8 m/s, whereas there was no significant difference in the age, grip strength, percentage of skeletal muscle, percentage of fat, and BMI between the 2 groups.

Then the predictive value of leg muscle strength for gait speed was analyzed by ROC curve (Fig. 1). In ROC analysis, curve away from the diagonal line, or in other words area under the curve (AUC) higher than 0.5 indicates a good diagnostic value. AUC was 0.731 (95% confidence interval [CI], 0.546–0.916) for the left leg and 0.744 (95% CI, 0.565–0.922) for the right leg. In contrast, other parameters; age, BMI, percentage of skeletal muscle, grasp strength, did not show significant predictability (data not shown). The cutoff value was determined to be 3.65 N/kg body weight by Youden index, in which a value yielding the maximal "sensitivity + specificity − 1" is adopted.

Table 1
Background profiles of the study subjects.

Variable	Total (n = 43)	Men (n = 11)	Women (n = 32)	P-value[a]
Age, yr	82.9 ± 6.0	82.4 ± 6.5	83.1 ± 5.9	0.733
Height, cm	153.3 ± 8.6	164.2 ± 3.7	149.4 ± 6.1	<0.001
Weight, kg	50.7 ± 9.2	58.8 ± 6.0	47.8 ± 8.4	<0.001
Body mass index, kg/m^2	21.5 ± 2.8	21.9 ± 2.5	21.3 ± 3.0	0.610
Fat, %	30.7 ± 6.0	23.4 ± 4.9	33.4 ± 3.8	<0.001
Skeletal muscle, %	23.2 ± 3.3	27.9 ± 2.0	21.6 ± 1.8	<0.001

Values are presented as mean ± standard deviation.
[a] t-test.