

Original Paper

Relationship between Muscle Mass and Abdominal Muscle Thickness in Community-dwelling Elderly Women: A Cross-sectional Study

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Abstract

The aim of this study was to clarify the relationship between muscle mass and abdominal muscle thickness in elderly women. Thirty-five community-dwelling elderly women participated in this study. Muscle mass was measured using a multi-frequency bioelectrical impedance instrument. Definition of low muscle mass was based on the cutoff value of height-adjusted appendicular skeletal muscle ($< 5.7 \text{ kg/m}^2$) in the Consensus Report of the Asian Working Group for Sarcopenia. Muscle thickness of the rectus abdominis, external oblique, internal oblique, and transversus abdominis muscles were measured by B-mode ultrasound. The age, height, weight, body mass index, height-adjusted appendicular skeletal muscle mass, and each abdominal muscle thickness was compared between participants with and without low muscle mass. Prevalence of low muscle mass was 34.3% (n=12). The low muscle mass individuals presented significantly lower weight, body mass index, height-adjusted appendicular skeletal muscle mass, and muscle thickness of the rectus abdominis and external oblique muscles compared to the non-low muscle mass in the elderly. Muscle atrophy, in accordance with low muscle mass, was marked in the rectus abdominis and external oblique muscles among the abdominal muscles in community-dwelling elderly women.

1. Introduction

In Japan, the fifth leading cause of death is pneumonia¹⁾. For minimizing the risk of infection, expiratory flow plays an important role by expelling foreign substances and excess mucus from the lungs²⁾. Abdominal muscles including the rectus abdominis, external oblique, internal oblique, and transverse abdominis muscles primarily contribute to the production of forced expiration³⁾.

The loss of skeletal muscle mass is recognized in people with several diseases such as cancer, chronic heart failure, and chronic renal failure as well as aging⁴⁾. Recently, literature showed that loss of muscle mass was associated with peak expiratory flow, maximal inspiratory pressure, and maximal expiratory pressure⁵⁻⁷⁾. Additionally, low muscle mass is a potential predictor of mortality in individuals with aspiration pneumonia⁸⁾. Individuals with aspiration pneumonia with low muscle mass might be unable to expel

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aspirates sufficiently because of a lack of expiratory muscle strength. Therefore, it is important to consider factors that affect the reduction of expiratory muscle strength.

Previous studies have regarded age-related changes in abdominal muscle size^{9,10}. Rankin et al.⁹ reported a significant negative correlation between age and thickness of all abdominal muscles in healthy subjects (20-72 years). Ikezoe et al.¹⁰ showed that the thickness of the abdominal muscles except for the transversus abdominis, was significantly thinner in the independent elderly group (85.5 ± 5.5 years) compared with that in the young group (20.0 ± 0.8 years). However, little is known about the relationship between muscle mass loss and the atrophy of each abdominal muscle among elderly individuals. If there are different relationships between each abdominal muscle and muscle mass loss, exercises to prevent atrophying of the abdominal muscle that is associated with muscle mass loss could be selected for preventing the decrease of expiratory muscle strength. The aim of this study was to clarify the relationship between muscle mass and muscle thickness of the rectus abdominis, external oblique, internal oblique, and transversus abdominis muscles in elderly women and establish which abdominal muscle/s tend to atrophy.

2. Methods

2.1 Design and participants

This study used a cross-sectional design. Thirty-five community-dwelling elderly women able to perform activities of daily living involving walking independently participated in this study. Participants were recruited from the Outpatient Rehabilitation Center of the Shukumo Clinic in Okayama, Japan. Exclusion criteria included the following: inability to follow instructions related to cognitive dysfunction; history of orthopedic surgery in the lumbar spine; history of cancer, chronic heart failure, chronic renal failure, pulmonary disease, or neuromuscular disease. The Ethics Committee of the Kawasaki University of Medical Welfare approved the protocol (#18-037). Written informed consent was obtained from each subject before participation.

2.2 Muscle mass

Muscle mass was measured using a multi-frequency bioelectrical impedance instrument (MC-780A, TANITA Corp., Tokyo, Japan). The definition of low muscle mass was based on the cutoff value of height-adjusted appendicular skeletal muscle mass (appendicular skeletal muscle mass divided by height squared) ($< 5.7 \text{ kg/m}^2$) in the Consensus Report of the Asian Working Group for Sarcopenia¹¹.

2.3 Muscle thickness

A B-mode (Noblus, Hitachi Ltd., Tokyo, Japan) with a 18.5 MHz linear probe (L64) was used to perform ultrasound imaging of the muscle thicknesses of the right rectus abdominis, external oblique, internal oblique, and transversus abdominis muscles.

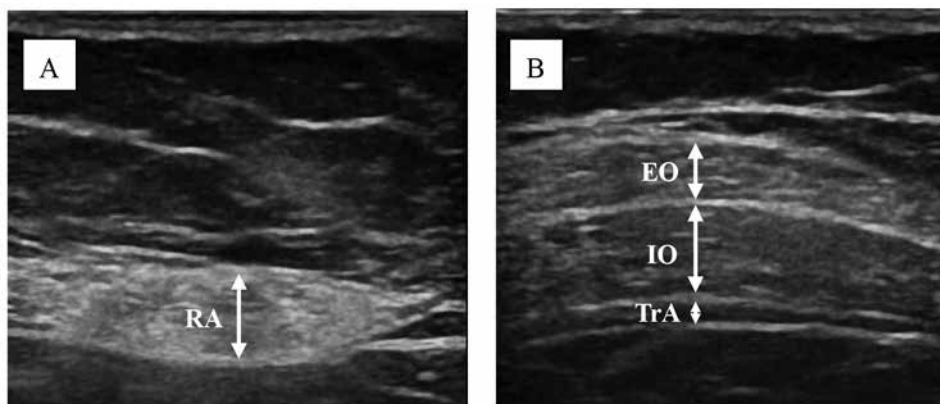


Figure 1 Abdominal muscle ultrasound images

A: The right rectus abdominis (RA) muscle; B: The right external oblique (EO), internal oblique (IO), and transversus abdominis (TrA) muscles

oblique, and transverse abdominis muscles (Figure 1). The subjects were in the supine position to perform ultrasound imaging of the abdominal muscles at rest. The rectus abdominis muscle was measured 3 cm lateral to the umbilicus on the right side of the body¹⁰. The external oblique, internal oblique, and transverse abdominis muscles were measured 2.5 cm anterior to the midaxillary line and at the midpoint between the inferior rib and iliac crest¹⁰. Measurements were performed by the experienced investigator who had 6 years of experience in musculoskeletal ultrasound. The probe was held using the minimum pressure required to achieve a clear image. Measurement of abdominal muscle thicknesses was performed at the end of a relaxed expiration. The abdominal muscle images were collected twice. The average values of the two trials were used in the analysis.

2.4 Statistical analysis

SPSS Statistics 23.0 (IBM Japan Inc., Tokyo, Japan) was used for statistical analysis. The Mann-Whitney's U test was performed to compare the obtained values between participants with and without low muscle mass. The significance level was selected as $p < 0.05$. The G-Power software (Franz Faul, University of Kiel, Germany) was also used to calculate the post-hoc power of the sample. To classify the effect size, a previous study categorizing absolute correlation coefficient values of 0.10-0.29, 0.30-0.49, and ≥ 0.50 as small, medium, and large, respectively, was used¹².

3. Results

The prevalence of low muscle mass was 34.3% ($n=12$) (Table 1). The elderly with low muscle mass presented a significantly lower weight, body mass index, height-adjusted appendicular skeletal muscle mass, and muscle thickness of the rectus abdominis and external oblique muscles compared to the elderly with non-low muscle mass.

Table 1 Median (first-third quartile) of obtained values

	Low muscle mass ($n=12$)	Non-low muscle mass ($n=23$)	p-value	Effect size	Power
Age (years)	88 (82-91)	82 (77-87)	0.060	0.66	0.42
Height (cm)	148.3 (142.0-151.8)	149.0 (145.0-154.0)	0.496	0.22	0.09
Weight (kg)	42.4 (35.2-46.0)	51.9 (46.7-55.8)	0.001	1.47	0.97
BMI (kg/m^2)	20.0 (17.7-21.0)	23.2 (20.7-24.8)	<0.001	1.59	0.99
Muscle mass (kg/m^2)	5.4 (4.7-5.6)	6.4 (6.1-7.0)	<0.001	2.14	1.00
Muscle thickness (mm)					
RA	5.9 (4.5-7.4)	7.0 (5.8-8.5)	0.046	0.73	0.49
EO	3.8 (2.8-5.0)	6.1 (4.3-8.2)	0.010	1.05	0.80
IO	6.3 (4.8-7.5)	7.3 (6.4-7.9)	0.244	0.32	0.13
TrA	2.3 (1.1-2.5)	2.1 (1.4-2.6)	0.520	0.30	0.12

BMI: body mass index; RA: rectus abdominis; EO: external oblique; IO: internal oblique; TrA: transversus abdominis

4. Discussion

In this study, the weight and body mass index of the elderly with low muscle mass was significantly lower than that of the elderly with non-low muscle mass. Literature reported that low muscle mass is associated with being underweight and low body mass indices¹³⁻¹⁵. The results of this study were similar to the literature. This study identified that the thickness of the rectus abdominis and external oblique muscles of the low muscle mass in the elderly was significantly thinner than that of the non-low muscle mass in the

elderly. However, there was no significant difference in the thickness of the internal oblique and transversus abdominis muscles between those with and without low muscle mass in the elderly. Ikezoe et al.¹⁰ reported that the influence of age-related atrophy was higher in the superficial compared to the deep antigravity trunk muscles. The active period involving more superficial and more deep muscles would be phasic (initial and burst movement) or continuous (prolonged holding), respectively¹⁶. The distance and spatial orientation of the muscle's line of force relative to the axis of movement determines the strength of a muscle action. The rectus abdominis and external oblique muscles have advantages compared to the internal oblique and transversus abdominis muscles for movements such as trunk flexion, rotation, and lateral flexion³. Hence, the reduction of thickness of the rectus abdominis and external oblique muscles might be marked among the abdominal muscles in the low muscle mass in the elderly.

A previous study reported that the fiber size of the expiratory intercostal muscles reduced after the age of 50 years¹⁷. The large fiber size of expiratory intercostal muscles might adapt to a non-ventilator rather than to a ventilator function so that the reduced size with age may reflect a more sedentary lifestyle¹⁷. Age-related atrophy is caused mainly by a loss of fibers, with no predominant effect on any fiber type, and to a lesser extent by a reduction in fiber size, mostly of type 2 fibers¹⁸. A previous study showed that the proportion of type 1 and type 2 fibers was about the same in all abdominal muscles¹⁹, which are similar to the majority of skeletal muscles²⁰. In this study, loss of fibers and type 2 fiber size reduction might occur in the rectus abdominis and external oblique muscles of the low muscle mass in the elderly. The decrease of the rectus abdominis and external oblique muscle thickness in accordance with the decrease of muscle mass might be induced by physical inactivity¹¹, though activities of participants and fiber size were not analyzed in this study. Physical activities such as aerobics, endurance exercise, and resistance training could be an intervention for muscle mass loss²¹⁻²³. The results of this study indicated that exercise enhancing activities of the rectus abdominis and external oblique muscles might be effective in preventing a decrease of expiratory muscle strength.

This study has some limitations. First, only female participants were recruited; hence, the influence of gender was not observed. Second, as both vital capacity and forced expiratory volume in one second were not measured using a spirometer, there may be concerns as to whether the subjects had normal pulmonary function. Third, the relationship between thickness of the abdominal muscles and muscle mass were indicated, but its association with respiratory strength was not. Fourth, sarcopenia is characterized by age-related decline of skeletal muscle plus low muscle strength and/or physical performance¹¹. Sarcopenia can be categorized by causes, such as age, activity, disease, and nutrition⁴. Several parameters should be measured to detect these associations. Finally, a cross-sectional design might not allow for cause-effect inferences. A longitudinal study would be needed to determine whether low muscle mass relates to abdominal muscle thickness in elderly individuals.

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