Kawasaki Journal of Medical Welfare Vol. 25, No. 2, 2020 23－28

Original Paper

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

Hiroshi ISHIDA*1, Chiharu KUROZUMI*1, Hiromi MATSUMOTO*1, Tadanobu SUEHIRO*1 and Susumu WATANABE*1

(Accepted November 7, 2019)

Key words: abdominal muscles, elderly, muscle thickness, muscle mass, ultrasound

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 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 pneumonia[1]. For minimizing the risk of infection, expiratory flow plays an important role by expelling foreign substances and excess mucus from the lungs[2]. Abdominal muscles including the rectus abdominis, external oblique, internal oblique, and transverse abdominis muscles primarily contribute to the production of forced expiration[3].

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 aging[4]. Recently, literature showed that loss of muscle mass was associated with peak expiratory flow, maximal inspiratory pressure, and maximal expiratory pressure[5-7]. Additionally, low muscle mass is a potential predictor of mortality in individuals with aspiration pneumonia[8]. Individuals with aspiration pneumonia with low muscle mass might be unable to expel

*1 Department of Rehabilitation, Faculty of Health Science and Technology, Kawasaki University of Medical Welfare, Kurashiki, 701-0193, Japan
E-Mail: ishida@mw.kawasaki-m.ac.jp

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 kg/m^2) in the Consensus Report of the Asian Working Group for Sarcopenia[11].

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

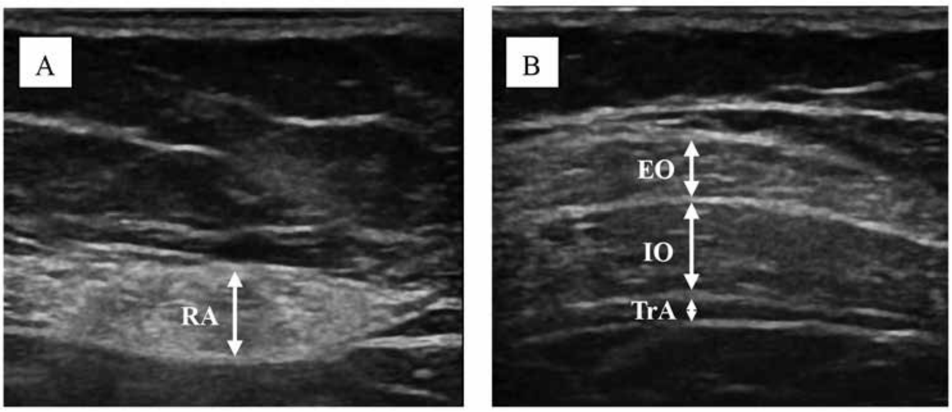

Figure 1 Abdominal muscle ultrasound images

A: The right rectus abdominis (RA) muscle; B: The right external oblique (EO), internal oblique (IO), and transverse 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 body[10]. 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 crest[10]. 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, Univesity 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 used[12].

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 indices[13-15]. 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), respectively[16]. 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 flexion[3]. 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 years[17]. 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 lifestyle[17]. 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 fibers[18]. A previous study showed that the proportion of type 1 and type 2 fibers was about the same in all abdominal muscles[19], which are similar to the majority of skeletal muscles[20]. 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 inactivity[11], 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 loss[21-23]. 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 performance[11]. Sarcopenia can be categorized by causes, such as age, activity, disease, and nutrition[4]. 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.

Acknowledgements

The authors would like to thank Hikari MORIYOSHI at the Shukumo Clinic for assistance with the data collection. This work was supported by JSPS KAKENHI Grant Number 15K16383.

References

1. Ministry of Health, Labor and Welfare in Japan : *Trends in leading causes of death*. https://www.mhlw.go.jp/english/database/db-hw/populate/dl/03.pdf, 2018. (March 19, 2019)
2. McCool FD : Global physiology and pathophysiology of cough: ACCP evidence-based clinical practice guidelines. *Chest*, **129**(1 Suppl), S48-53, 2006.
3. Neumann DA : *Kinesiology of the musculoskeletal system: Foundations for rehabilitation*. 2nd ed, Mosby, St. Louis, 2010.
4. Cruz-Jentoft AJ, Baeyens JP, Bauer JM, Boirie Y, Cederholm T, Landi F, Martin FC, Michel JP, Rolland Y, Schneider SM, Topinková E, Vandewoude M and Zamboni M : Sarcopenia: European consensus on

definition and diagnosis: Report of the European Working Group on Sarcopenia in Older People. *Age and Ageing*, **39**(4), 412-423, 2010.

5. Shin HI, Kim DK, Seo KM, Kang SH, Lee SY and Son S : Relation between respiratory muscle strength and skeletal muscle mass and hand grip strength in the healthy elderly. *Annals of Rehabilitation Medicine*, **41**(4), 686-692, 2017.
6. Ohara DG, Pegorari MS, Oliveira Dos Santos NL, de Fátima Ribeiro Silva C, Monteiro RL, Matos AP and Jamami M : Respiratory muscle strength as a discriminator of sarcopenia in community-dwelling elderly: A cross-sectional study. *The Journal of Nutrition, Health & Aging*, **22**(8), 952-958, 2018.
7. Kera T, Kawai H, Hirano H, Kojima M, Fujiwara Y, Ihara K and Obuchi S : Relationships among peak expiratory flow rate, body composition, physical function, and sarcopenia in community-dwelling older adults. *Aging Clinical and Experimental Research*, **30**(4), 331-340, 2018.
8. Maeda K and Akagi J : Muscle mass loss is a potential predictor of 90-day mortality in older adults with aspiration pneumonia. *Journal of the American Geriatrics Society*, **65**(1), e18-e22, 2017.
9. Rankin G, Stokes M and Newham DJ : Abdominal muscle size and symmetry in normal subjects. *Muscle & Nerve*, **34**(3), 320-326, 2006.
10. Ikezoe T, Mori N, Nakamura M and Ichihashi N : Effects of age and inactivity due to prolonged bed rest on atrophy of trunk muscles. *European Journal of Applied Physiology*, **112**(1), 43-48, 2012.
11. Chen LK, Liu LK, Woo J, Assantachai P, Auyeung TW, Bahyah KS, Chou MY, Chen LY, Hsu PS, Krairit O, Lee JS, Lee WJ, Lee Y, Liang CK, Limpawattana P, Lin CS, Peng LN, Satake S, Suzuki T, Won CW, Wu CH, Wu SN, Zhang T, Zeng P, Akishita M and Arai H : Sarcopenia in Asia: Consensus report of the Asian Working Group for Sarcopenia. *Journal of American Medical Directors Association*, **15**(2), 95-101, 2014.
12. Mizumoto A and Tateuchi O : Basic and considerations for reporting effect sizes in research papers. *Study in English Language Teaching*, **31**, 57-66, 2008. (In Japanese, translated by the author of this article)
13. Lau EM, Lynn HS, Woo JW, Kwok TC and Melton LJ 3rd : Prevalence of and risk factors for sarcopenia in elderly Chinese men and women. *The Journal of Gerontology. Series A: Biological Sciences and Medical Sciences*, **60**(2), 213-216, 2005.
14. Iannuzzi-Sucich M, Prestwood KM and Kenny AM : Prevalence of sarcopenia and predictors of skeletal muscle mass in healthy, older men and women. *The Journal of Gerontology. Series A: Biological Sciences and Medical Sciences*, **57**(12), M772-777, 2002.
15. Sampaio RA, Sewo Sampaio PY, Yamada M, Yukutake T, Uchida MC, Tsuboyama T and Arai H : Arterial stiffness is associated with low skeletal muscle mass in Japanese community-dwelling older adults. *Geriatrics & Gerontology International*, **14**(Suppl 1), 109-114, 2014.
16. Richardson CA, Hodges P and Hides J : *Therapeutic exercise for lumbopelvic stabilization: A motor control approach for the treatment and prevention of low back pain.* 2nd ed, Churchill Livingstone, London, 2004.
17. Mizuno M : Human respiratory muscles: Fibre morphology and capillary supply. *The European Respiratory Journal*, **4**(5), 587-601, 1991.
18. Lexell J, Taylor CC and Sjöström 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. *Journal of the Neurological Sciences*, **84**(2-3), 275-294, 1988.
19. Häggmark T and Thorstensson A : Fibre types in human abdominal muscles. *Acta Physiologica Scandinavica*, **107**(4), 319-325, 1979.
20. Polgar J, Johnson MA, Weightman D and Appleton D : Data on fibre size in thirty-six human muscles: An autopsy study. *Journal of the Neurological Sciences*, **19**(3), 307-318, 1973.
21. Kubo K, Ishida Y, Suzuki S Komuro T, Shirasawa H, Ishiguro N, Shukutani Y, Tsunoda N, Kanehisa H and Fukunaga T : Effects of 6 months of walking training on lower limb muscle and tendon in elderly. *Scandinavian Journal of Medicine & Science in Sports*, **18**(1), 31-39, 2008.
22. Mitchell CJ, Churchward-Venne TA, West DW, Burd NA, Breen L, Baker SK and Phillips SM : Resistance exercise load does not determine training-mediated hypertrophic gains in young men. *Journal*

of Applied Physiology, **113**(1), 71-77, 2012.
23. Kamel HK : Sarcopenia and aging. *Nutriton Reviews*, **61**(5 Pt 1), 157-167, 2003.