J. Phys. Ther. Sci. 30: 1424–1427, 2018

The Journal of Physical Therapy Science

Original Article

Correlation between skeletal muscle mass index and parameters of respiratory function and muscle strength in young healthy adults according to gender

Yohei Sawaya, RPT, MS[1, 2)*], Masahiro Ishizaka, RPT, PhD[3)], Akira Kubo, RPT, PhD[3)], Kaori Sadakiyo, RPT, MS[3)], Akihiro Yakabi, RPT, PhD[3)], Tamae Sato, RPT, MS[1, 3)], Takahiro Shiba, RPT[2)], Ko Onoda, RPT, PhD[3)], Hitoshi Maruyama, RPT, PhD[4)]

1) Division of Physical Therapy, Doctoral Program in Health Sciences, Graduate School of Health and Welfare Sciences, International University of Health and Welfare: 2600-1 Kitakanemaru, Otawara city, Tochigi 324-8501, Japan

2) Nishinasuno General Home Care Center, Department of Day Rehabilitation, Care Facility for the Elderly "Maronie-en", Japan

3) Department of Physical Therapy, School of Health Science, International University of Health and Welfare, Japan

4) Graduate School of International University of Health and Welfare, Japan

Abstract. [Purpose] The purpose was to determine the correlation between the skeletal muscle mass index and parameters of respiratory function and muscle strength in young healthy adults as predictors of sarcopenia in association with aging and respiratory diseases. [Participants and Methods] Participants were 41 males and 37 females with a mean age of 19.5 ± 1.5 years. The following were measured: body composition (skeletal muscle mass index), respiratory function (vital capacity, inspiratory reserve volume, expiratory reserve volume, inspiratory capacity, forced vital capacity, one-second forced expiratory volume, peak expiratory flow rate), and respiratory muscle strength (maximum inspiratory pressure, maximum expiratory pressure). Correlations between the skeletal muscle mass index and parameters of respiratory function and respiratory muscle strength were assessed using Pearson's coefficient. [Results] The total skeletal muscle mass index showed a positive correlation with all items. The male skeletal muscle mass index showed a positive correlation with respiratory function excluding inspiratory reserve volume, expiratory reserve volume, maximum inspiratory pressure, and maximum expiratory pressure. The female skeletal muscle mass index showed a positive correlation with all respiratory functions including inspiratory reserve volume and expiratory reserve volume, but was not associated with respiratory muscle strength. [Conclusion] The skeletal muscle mass index showed a positive correlation with respiratory function and respiratory muscle strength. Gender-based features were correlated with respiratory muscle strength in males and lung capacity in females.

Key words: Skeletal muscle mass index, Respiratory function, Respiratory muscle strength

(This article was submitted Jul. 18, 2018, and was accepted Sep. 12, 2018)

INTRODUCTION

Aging is associated with decreasing skeletal muscle. This may result in sarcopenia, which impairs physical capability. Ag-

*Corresponding author. Yohei Sawaya (E-mail: 18s3024@g.iuhw.ac.jp)

ing also leads to muscle fiber size decrease, muscle strength and power loss, and fast-to-slow fiber type shift[1]. In contrast to changes with aging, the rate of slow fiber type shift has been reported to decrease with chronic obstructive pulmonary disease (COPD)[2]. However, reasons underlying these two contrasting outcomes remain unclear. Additionally, 15% prevalence of sarcopenia in patients with COPD has been reported[3]. Baumgartner reported skeletal muscle mass index (SMI) as a parameter of muscle mass[4]. SMI was calculated by dividing the muscle mass of limbs by the square of height[4]. Sanada calculated the reference value of SMI in patients with sarcopenia as 6.87 kg/m^2 for males and 5.46 kg/m^2 for females in Japan[5]. In regard to healthy adults, muscle mass is moderately correlated with respiratory function in terms of forced vital capacity (FVC), %FVC, one-second forced expiratory volume (FEV1), and FEV1/FVC ratio[6]. In recent years, in addition to respiratory function, respiratory muscle strength can also be evaluated, such as maximum inspiratory pressure (PImax) or maximum expiratory pressure (PEmax). However, only a few studies have considered the association between skeletal muscle mass and respiratory muscle strength. In particular, there are few reports on the relationships between SMI, respiratory function, and muscle strength. In order to elucidate muscle mass and respiratory changes with aging and COPD, their association among healthy adults should be clarified. The purpose of this study was to clarify the correlation between skeletal muscle mass index and parameters of respiratory function and muscle strength in young healthy adults, with a focus on gender features given the difference of respiratory function between genders. When studying elderly, it is necessary to adjust for age, smoking, and alcohol record[7]. Life history affects respiratory function. Therefore, in this study, young healthy adults who have few biases in daily living and less affected by aging, were focused on.

PARTICIPANTS AND METHODS

Participants, who were students of the International University of Health and Welfare (IUHW), were recruited through convenience sampling. A total of 78 participants, of which 41 were males and 37 were females (age, 19.5 ± 1.5 years), were enrolled. The exclusion criteria were respiratory and cardiovascular diseases. Participants were provided information about this study before they volunteer. This study was approved by the Ethics Review Committee of IUHW, Japan (approval number: 16-Io-171, 2016). Body composition, respiratory function, and respiratory muscle strength of all participants were measured. Body composition was measured by direct segmental multifrequency bioelectrical impedance analysis method (DSM-BIA) (Inbody520, Biospace, Japan). SMI was calculated by dividing the muscle mass of limbs by the square of height[1]. Respiratory function and muscle strength were measured using Autospiro (AS-507, Minato Medical Science, Japan) and attached unit (AAM377, Minato Medical Science, Japan). Each participant performed three acceptable SVC and FVC maneuvers according to the American Thoracic recommendations and European Respiratory Society[8]. Respiratory function and muscle strength were determined by measuring vital capacity (VC), inspiratory reserve volume (IRV), expiratory reserve volume (ERV), inspiratory capacity (IC), FVC, FEV1, peak expiratory flow rate (PEFR), PImax, peak inspiratory pressure (PIpeak), PEmax, peak expiratory pressure (PEpeak). PImax and PEmax were the maximum pressure averaged over 1 to 2 seconds. PIpeak and PEpeak were the highest value regardless of time. Characteristics and results between males and females were compared by unpaired t-test. Moreover, relationships between SMI and parameters of respiratory function and muscle strength were assessed by Pearson's correlation coefficient. SPSS version 22 (IBM, Japan) was used for all analyses. A p value <0.05 was considered statistically significant.

RESULTS

Table 1 shows characteristics and results of respiratory function, respiratory muscle strength, and SMI in total, male and female participants. In the unpaired t-test between male and female participants, significant differences were found in all items except for age and body mass index. Table 2 shows Pearson's correlation coefficient between SMI and respiratory function as well as between SMI and respiratory muscle strength in total and in male and female participants. The SMI of all participants had a positive correlation with all measured items. The SMI of male participants had a positive correlation with respiratory function excluding IRV and ERV, PEmax, and PEpeak. The SMI of female participants had a positive correlation with all respiratory function including IRV and ERV, but it was not associated with respiratory muscle strength.

DISCUSSION

The purpose of this study was to clarify the correlation between SMI and respiratory function as well as between SMI and respiratory muscle strength. The SMI of all participants was associated with respiratory function and muscle strength. This suggested that greater muscle mass may contribute to respiratory function and muscle strength. This result was similar to that in a previous study[6]. Interestingly enough, the SMI of male participants had a positive correlation with VC, IC, FVC, FEV1, PEFR, PEmax, and PEpeak, but it was not associated with IRV and ERV. The SMI of female participants had a positive correlation with all respiratory function including IRV and ERV, but it was not associated with respiratory muscle strength. This result suggested that the SMI of male participants was associated with respiratory muscle strength, while the SMI of female participants was associated with lung capacity especially. Two studies reported that female's respiratory function may be influenced by the thoracic volume. One report suggested that the thoracic volume of females was likely to expand due

Table 1. Characteristics and results of respiratory function, respiratory muscle strength, and SMI in total, male and female

	Total (n=77)	Male (n=40)	Female (n=37)
Characteristics			
Age (years)	19.5 ± 1.5	19.7 ± 2.0	19.2 ± 0.4
Height (cm)*	166.1 ± 8.3	172.3 ± 5.1	159.5 ± 5.3
Body weight (kg)*	57.9 ± 9.0	62.7 ± 7.2	52.7 ± 7.7
BMI (kg/m^2)	20.9 ± 2.3	21.1 ± 2.0	20.7 ± 2.5
Respiratory function			
VC (l)*	3.8 ± 0.9	4.4 ± 0.6	3.1 ± 0.4
IRV (l)*	1.6 ± 0.6	1.9 ± 0.5	1.2 ± 0.3
ERV (l)*	1.5 ± 0.4	1.8 ± 0.4	1.3 ± 0.3
IC (l)*	2.3 ± 0.6	2.7 ± 0.6	1.8 ± 0.3
FVC (l)*	3.8 ± 0.8	4.4 ± 0.6	3.1 ± 0.4
FEV1 (l)*	3.4 ± 0.8	4.0 ± 0.5	2.8 ± 0.5
PEFR (l/sec)*	7.2 ± 2.3	8.9 ± 1.7	5.3 ± 1.3
Respiratory muscle strength			
PImax (kPa)*	6.9 ± 2.7	8.4 ± 2.5	5.3 ± 1.9
PIpeak (kPa)*	7.5 ± 2.8	9.1 ± 2.5	5.8 ± 2.0
PEmax (kPa)*	7.7 ± 2.4	9.1 ± 2.0	6.1 ± 1.7
PEpeak (kPa)*	8.4 ± 2.5	10.0 ± 2.0	6.6 ± 1.8
Body composition			
SMI (kg/m^2)*	6.9 ± 0.9	7.7 ± 0.4	6.1 ± 0.6

Unpaired t-test between male and female: *$p<0.05$.
VC: vital capacity; IRV: inspiratory reserve volume; ERV: expiratory reserve volume; IC: inspiratory capacity; FVC: forced vital capacity; FEV1: one-second forced expiratory volume; PEFR: peak expiratory flow rate; PImax: maximum inspiratory pressure; PIpeak: peak inspiratory pressure; PEmax: maximum expiratory pressure; PEpeak: peak expiratory pressure; SMI: skeletal muscle mass index.

Table 2. Pearson's correlation coefficient between SMI and parameters of respiratory function and respiratory muscle strength

	Total (n=77)	Male (n=40)	Female (n=37)
Respiratory function			
VC (l)	0.82**	0.50**	0.51**
IRV (l)	0.63**	0.26	0.40*
ERV (l)	0.61**	0.17	0.33*
IC (l)	0.73**	0.41**	0.47**
FVC (l)	0.82**	0.48**	0.44**
FEV1 (l)	0.80**	0.41**	0.35*
PEFR (l/sec)	0.76**	0.34*	0.35*
Respiratory muscle strength			
PImax (kPa)	0.56**	0.18	0.13
PIpeak (kPa)	0.58**	0.22	0.17
PEmax (kPa)	0.66**	0.35*	0.27
PEpeak (kPa)	0.69**	0.37*	0.32

Pearson's correlation coefficient *$p<0.05$, **$p<0.01$.

to increased abdominal volume during pregnancy[9]. In recent years, this expanding thoracic volume is measured as chest expansion difference, and it is clear that females tend to have increased thoracic volume through chest expansion compared to male. Another report suggested that airway resistance of males was higher than that of the females because the lung parenchyma and airway grew disproportionately[10]. This mechanism reported the involvement of androgen. If age and height are the same, VC of males will be higher than that of females. On the contrary, the FEV1 of females may be higher than that of males matched for age and height. The gender differences among growth periods were thought to reflect the relationships and features in respiratory muscle of male and lung capacity of females. In many items, although a significant difference was observed in total values, no significant difference between males and females or in decrease of correlation coefficients was observed. This indicates the influence of many factors other than gender, including body size, muscle mass, and fat. This study has some limitations. Only univariate analysis was carried out; multivariate analysis was not performed. Moreover, the sample size was small and limited to students of one university department. The present study demonstrated the relationship between SMI and parameters of respiratory function and muscle strength. In the future, similar measurements for healthy elderly, elderly with sarcopenia, and patients with respiratory disease might be undertaken and analyzed. Furthermore, a respiratory physiotherapy may be developed considering SMI as important index.

Funding

This work was supported by the Japan Society for the Promotion of Science (JSPS KAKENHI 18K17758).

Conflict of interest

The authors declare no conflict of interest.

REFERENCES

1) Miljkovic N, Lim JY, Miljkovic I, et al.: Aging of skeletal muscle fibers. Ann Rehabil Med, 2015, 39: 155–162. [Medline] [CrossRef]
2) Gea J, Pascual S, Casadevall C, et al.: Muscle dysfunction in chronic obstructive pulmonary disease: update on causes and biological findings. J Thorac Dis, 2015, 7: E418–E438. [Medline]
3) Jones SE, Maddocks M, Kon SS, et al.: Sarcopenia in COPD: prevalence, clinical correlates and response to pulmonary rehabilitation. Thorax, 2015, 70: 213–218. [Medline] [CrossRef]
4) Baumgartner RN, Koehler KM, Gallagher D, et al.: Epidemiology of sarcopenia among the elderly in New Mexico. Am J Epidemiol, 1998, 147: 755–763. [Medline] [CrossRef]
5) 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. [Medline] [CrossRef]
6) Takahashi H, Ishizaka M, Kubo A, et al.: Relationship between skeletal muscle mass and respiratory function in healthy adults. Rigakuryoho Kagaku, 2017, 32: 429–433 (In Japanese). [CrossRef]
7) Moon JH, Kong MH, Kim HJ: Implication of sarcopenia and sarcopenic obesity on lung function in healthy elderly: using Korean national health and nutrition examination survey. J Korean Med Sci, 2015, 30: 1682–1688. [Medline] [CrossRef]
8) American Thoracic Society/European Respiratory Society: ATS/ERS statement on respiratory muscle testing. Am J Respir Crit Care Med, 2002, 166: 518–624. [Medline] [CrossRef]
9) Bellemare F, Jeanneret A, Couture J: Sex differences in thoracic dimensions and configuration. Am J Respir Crit Care Med, 2003, 168: 305–312. [Medline] [CrossRef]
10) Mead J: Dysanapsis in normal lungs assessed by the relationship between maximal flow, static recoil, and vital capacity. Am Rev Respir Dis, 1980, 121: 339–342. [Medline]