Muscle tissue content and spirometry variables in a nursing home women

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ABSTRACT

Introduction: It is unclear how exactly sarcopenia affects pulmonary function.
The aim of the conducted research was to examine whether the level of skeletal muscle mass development differentiates ventilatory function in older women living in nursing homes in Poland.
Materials and methods: Forty-four women, aged 73 ±3, were divided into 2 groups: with less total muscle mass (group 1, n = 21) and with higher total muscle mass (group 2, n = 23) content of body muscle tissue. It was assumed that the subjects were not underweight or obese. They were non-obese, non-smokers, and with no overt diseases other than sarcopenia. The assessment of pulmonary function was based on spirometry. The following variables were evaluated: BMI, forced vital capacity (FVC), forced expiratory volume in first second (FEV_1) and FEV_1/FVC.
Results: Women with normal muscle mass content enjoyed significantly higher mean levels of the following variables: FVC $p < 0.0001$, FEV_1 $p < 0.0001$, FEV_1/FVC $p = 0.009$.
Conclusions: It seems likely that the decrease in muscle mass of old age may substantially impact the ventilatory function in women.
Keywords: spirometry; gerontology; sarcopenia; muscle tissue; nursing home women.

INTRODUCTION

It is unclear how exactly sarcopenia affects pulmonary function. It seems interesting to observe whether there is a correlation between the content of muscle mass and spirometry parameters. It is known that obesity is associated with respiratory dysfunction. However, studies by other authors indicate that BMI values slightly above the reference values are not considered to have an impact on the respiratory system. [1]. It has been suggested that low body weight may be associated with decreased respiratory muscle function, but the exact mechanism is not known [2]. Since body composition changes with the change in body weight, it seems interesting to check whether there is a relationship between body composition and respiratory function. Especially between the percentage of muscle mass and the parameters assessing the functions of the respiratory system. With age, the aging process leads to a gradual loss of lean body mass. This process makes it difficult for seniors to undertake effective physical activity [3]. It can be assumed that this is one of the leading factors that reduce the functions of the respiratory system. A decrease in the level of exercise capacity is associated with a decrease in the adaptation of the respiratory system, among others, to physical exertion. One of the unfavorable processes of involution in the context of aging of the body is sarcopenia. Sarcopenia increases risk of falls and fractures, impairs ability to perform activities of daily living. It is often associated with cardiac disease and respiratory disease [4, 5, 6, 7, 8]. It is unclear how exactly reduced muscle mass content affects pulmonary function.

The aim of the conducted research was to examine whether the level of skeletal muscle mass (SMM) development differentiates ventilatory function in older women living in nursing homes in Poland.

MATERIALS AND METHODS

The research was done in several nursing homes in the southwestern region in Poland. Forty-four women, aged 73 ±3, were divided into 2 groups: with less total muscle mass (group 1, n = 23) and with higher total muscle mass (group 2, n = 21) content of body mass. It was assumed that the subjects were not underweight or obese. They were non-obese, non-smokers, and with no overt diseases.

Body mass index was assessed in the subjects. Body mass index is a quick and inexpensive screening method for weight category. It is calculated by dividing a person's weight in kilograms by the square of height in meters. Also, feedback from dietitians working with older subjects indicates that 72.5% of those using BMI express concerns that it is of limited use for practical reasons or that the reference range (20–25 kg/m²) is not appropriate to older subjects [9]. There is an ongoing debate about the ideal BMI range for older adults. A BMI range of 23–29 kg/m² is proposed as normal for people over 65 years of age [10, 11]. The mean BMI value in the subjects was 26.3 kg/m² ±2.6. There were no significant differences in age and BMI between groups 1 and 2. The SMM was measured by a body composition analyzer ACCUNIQ BC310. Uses Bioelectrical Impedance Analysis.

The assessment of pulmonary function was based on spirometry. Respiratory parameters were measured using the BTL – 08 Spiro Pro spirometer.

The following variables were evaluated: forced vital capacity (FVC), forced expiratory volume in first second (FEV_1) and FEV_1/FVC ratio. Forced vital capacity is the largest volume of air that can be blown out of the lungs during max, rapid exhalation. Forced expiratory volume in first second is the volume of air expelled from the lungs during the first second of max forced exhalation; FEV_1/FVC is calculated by dividing FEV_1 by FVC. It provides valuable information about airflow obstruction [12].

Ethics

The study protocol was approved by the Bioethics Committee of the Opole Medical School, Poland (permission no. KB/202/FI/2019). All patients provided informed consent and were informed that they could withdraw from the study at any stage. The study was carried out following the tenets of the Declaration of Helsinki and Good Clinical Practice guidelines.

Statistical analysis

Descriptive statistics were used. The mean, standard deviation, median were calculated. The nature of the parameter distributions was examined in terms of compliance with the model normal distribution (normality of the distribution). The Shapiro–Wilk test was used for the analysis.

The distributions of FVC and FEV_1 variables turned out to be normal. The distributions of the other variables deviate significantly from the model normal distribution. Therefore, the significance of the differences in the arithmetic mean values of the features FVC and FEV_1 was assessed by the Student's T-test for independent variables; for the other features, the significance of the differences in the central tendency (in this case, the median) was assessed by the Mann–Whitney U-test (a nonparametric equivalent of the T-test).

All calculations were done using Statistica version 13.3 (TIBCO Inc., USA). In the assessment of statistical significance, the level of p-value ≤ 0.05 was assumed.

RESULTS

Tables 1 and 2 present basic statistics for the group of women with lower SMM = 19.2 ±1.8 (Tab. 1) and for the group of residents with higher SMM = 26 ±2.1 (Tab. 2).

The results of spirometry parameters and the muscle mass content of the 2 groups of women were compared in order to determine the significance of the differences (Tab. 3, 4).

The values of mean FVC and FEV_1 are significantly higher in the control group (group 2).

TABLE 1. Basic statistics for group 1, women with less total muscle mass

Variables	Mean	Median	Minimum	Maximum	Variance	Standard deviation	Skewness	Kurtosis
FVC (L)	1.5	1.4	1.0	2.2	0.1	0.3	0.5	−0.9
FEV_1 (L)	1.2	1.2	0.5	2.0	0.1	0.4	−0.1	−0.8
FEV_1/FVC (%)	77.8	79.7	42.0	95.8	132.5	11.5	−1.6	3.7
SMM (kg)	19.3	19.0	14.5	21.9	3.3	1.8	−0.6	0.8
BMI (kg/m²)	25.6	27.7	23.2	29.0	11.3	2.4	0.6	−1.2
Age	72.9	70.0	70.0	76.0	11.3	3.0	−1.0	−0.4

TABLE 2. Basic statistics for group 2, women with higher total muscle mass

Variables	Mean	Median	Minimum	Maximum	Variance	Standard deviation	Skewness	Kurtosis
FVC (L)	2.1	2.1	1.1	3.3	0.2	0.4	0.5	1.1
FEV_1 (L)	1.6	1.5	1.1	2.1	0.1	0.3	−0.02	−1.1
FEV_1/FVC (%)	86.9	87.4	71.0	100.0	91.5	9.6	−0.1	−1.2
SMM (kg)	26.0	26.3	22.2	34.5	9.9	3.1	0.9	1.0
BMI (kg/m²)	27.0	29.0	23.0	29.0	3.9	2.0	−1.1	−0.2
Age	73.1	70.0	70.0	76.0	17.0	3.0	0.7	−1.5

TABLE 3. Significance of differences in arithmetic means of FVC and FEV_1 variables – Student's T-test

Variables	Mean group 1	Mean group 2	t	df	p	n group 1	n group 2	Standard deviation group 1	Standard deviation group 2	Quotient F	p
FVC (L)	1.463	2.061	−4.722	42	0.000026	23	21	0.349	0.486	1.937	0.135
FEV_1 (L)	1.19609	1.62572	−4.213	42	0.000131	23	21	0.38542	0.27633	1.945409	0.1396

TABLE 4. Significance of differences in median values of FEV_1/FVC variables; SMM – Mann–Whitney U-test

Variables	Sum of ranks group 1	Sum of ranks group 2	U	Z	p	Z	level p	n group 1	n group 2	2*
FEV_1/FVC (%)	407.000	583.000	131.000	−2.5964	0.009421	−2.5971	0.009403	23	21	0.0087
SMM (kg)	276.000	714.000	0.000	−5.6745	0.000000	−5.6803	0.000000	23	21	0.000000

* FEV_1/FVC – the mean value of the trait (median) is significantly higher in the control group (group 2); SMM – the mean value of the trait (median) is significantly higher in the control group (group 2)

DISCUSSION

On the basis of the presented research, in the population of older women, a significant dependence of the assessed respiratory parameters on the content of muscle mass is visible. In the group with significantly higher SMM content, significantly higher FVC, FEV_1, FEV_1/FVC parameters are observed. They describe better respiratory efficiency in the group without the risk of sarcopenia. Similar observations are described by other authors. Rossi et al. reports that an increase in abdominal fat and a decrease in lean muscle mass – fat free mass index are significant predictors of the deterioration of lung function in older adults. Older patients who develop both abdominal fat gain and FFM loss are most likely to have a decline in lung function [13]. The research by Lazarus et al. prove that FVC, which is a measure of lung ventilation function, is not significantly related to body weight or BMI. On the other hand, index FVC is significantly lower in people with a higher body fat content. It is higher with a higher content of lean mass [1]. This suggests that this effect may result in a higher total muscle mass content in lean body mass, as confirmed by this study. Previous studies that analyzed the relationship between body weight, BMI, and spirometry parameters did not take into account body composition [14]. Forced inhalation requires muscle contraction to overcome air pressure over a large area of the chest wall The relationship between respiratory muscle strength and ventilation function has previously been noted among older adults [15]. A systematic decrease in the percentage of muscle mass may be the main factor in reducing the values of respiratory parameters measured in this study. Sarcopenia refers to the loss of SMM and degeneration of muscle strength associated with aging among older people, even with unchanging body weight [16]. There are reports that indicate an improvement in muscle mass content in the elderly through the use of systematic training, especially those containing components of resistance exercises [17]. Properly selected physical training in the population of elderly people with a symptom of sarcopenia would most likely also improve the value of respiratory parameters by increasing the strength of respiratory muscles. Spirometry is the single most important test for the evaluation of respiratory function and screening of general respiratory health. The respiratory system is one of the most important systems that contributes to the development of good aerobic capacity of the body [18]. Between the ages 25–80 years, pulmonary function and aerobic capacity each decline by ~40%. While the predominant factor limiting exercise in the elderly likely resides within the function of the muscles of ambulation, muscle function is (at least partially) rescued by exercise training [19]. Loss of muscle fibers in the aging process is a well-known issue, cited by many authors [20]. This applies to the muscles responsible for motor skills and the muscles responsible for the mechanics of breathing. The etiology of the decrease in respiratory function with age is multifactorial. It is related to the control of ventilation, lung mechanics and the function of respiratory muscles. Accelerated ventilation in response to loads is most likely caused by an increase in dead space in the alveoli [21]. With age, structural changes occur in the lungs, which affect the reduction of spirometry parameters and the efficiency of the respiratory system [22]. Over time, chest wall compliance decreases due to calcification of costal cartilage, with increased prevalence of both spinal kyphosis and osteoporosis-associated vertebral fractures potentially contributing [23]. Respiratory muscle strength decreases with age [24]. Some authors report that the loss of respiratory muscle strength is not mainly related to the loss of muscle fibers, but to a change in collagen metabolism (collagen concentration and cross-linking increases) appear responsible for increased stiffness of this muscle [25]. Spinal kyphosis and increased chest anterior–posterior diameter that occur with age likely contribute to decreased diaphragmatic function, one of the main respiratory muscles [26]. However, the significant relationship between the reduced muscle mass content and the obtained spirometry parameters at a lower level shows that the loss of muscle mass is an important indicator of the decrease in respiratory efficiency. It is likely to be one of the key factors in the decline of this system with ageing, which would require more extensive research. Other authors have reported that physical exercise can significantly improve lung function, and that both VC, FEV_1, and FVC are increased [27, 28, 29]. The authors' research also indicates that people with higher levels of physical activity have higher spirometry parameters than less active people of the same age, gender, and body measures [30, 31]. Analyzing the above relationships, it can be assumed that systematic, properly selected training in the elderly should improve the function of the respiratory system and slow down regression processes related to this system.

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