Relationship between body fat percentage and forced vital capacity in adults with normal body mass index

RA Safira¹ and N Nusdwinuringtyas²*

¹Master of Medical Education Program, Faculty of Medicine, Universitas Indonesia, Jakarta, 10430, Indonesia
²Department of Physical Medicine and Medical Rehabilitation, Faculty of Medicine, Universitas Indonesia, Jakarta, 10430, Indonesia

*E-mail: nury_nus@yahoo.com

Abstract. Lung function tests are widely used to evaluate lung health conditions, and measuring the forced vital capacity is a major tool in this field. The impact of body fat percentage on lung function has rarely been evaluated. This study aimed to evaluate the relationship between body fat percentage and forced vital capacity. This was a cross-sectional study using 62 subjects who were identified from secondary data and selected by simple random sampling. Data were analyzed using the Kolmogorov–Smirnov normality test and the Pearson correlation test. This study found no correlation between body fat percentage and forced vital capacity, as measured by p > 0.001, for both male and female groups. Thus, the study revealed no significant correlation between body fat percentage and forced vital capacity.

1. Introduction
Various lung function tests are used to assess and diagnose various pulmonary functionalities, and one of the main tools in this regard is the forced vital capacity (FVC), which helps to describe the elasticity of lung tissue. The presence of a restrictive lung disorder can often be detected from FVC. The value of FVC can be compared with a subject’s body mass index (BMI), i.e., the ratio of body weight to height [1], which is widely used to classify a person as being underweight, normal, overweight, or obese [2]. Although BMI is a widely used metric regarding overall body composition, it does not indicate the amount of actual fat in the body [3], although it is recognized that greater obesity can decrease lung function [4]. In a 2012 cross-sectional study, Park et al. found a significant correlation between body fat content and FVC in both men and women with normal weight [4]. In contrast, a study conducted by Lad et al. found a correlation between fat content and FVC in the female group but not in the male group [5]. Therefore, our study sought to determine whether the fat content affects lung function by further exploring the relationship between fat content and FVC.

2. Methods
This study was a cross-sectional study to determine the relationship between fat content and FVC using secondary data from the “Six Minutes Walking Test” created by Nusdwinuringtyas and Epid from the Department of Cardiovascular Rehabilitation at the Cipto Mangunkusumo Hospital in
This research began with the preparation of the proposal in January 2017 and continued by obtaining secondary data, after which data analysis and report writing were performed, which was completed in October 2017. The study protocol had been approved by the Health Research Ethics Committee of Faculty of Medicine, Universitas Indonesia-Cipto Mangunkusumo Hospital.

The 62 individuals whose data was used in this study were chosen via simple random sampling. The inclusion criteria in this study were subjects with normal BMI (18.5–24.9 kg/m²) according to the WHO guidelines, those aged 18–40 years, and those with sedentary life habits. Exclusion criteria were subjects with smoking habits and those with lung function disorders, hypertension, diabetes, or other cardiovascular diseases.

Data on the body fat percentage and FVC were analyzed using SPSS version 22 for Windows. Because both datasets are numerical, the Kolmogorov–Smirnov test for normality was conducted before the correlation test. For data that was normally distributed, the Pearson correlation test was used, where p < 0.05 indicates a statistically significant relationship between the independent and dependent variables and p > 0.05 indicates no statistically significant relationship.

3. Results

Variables used in this study included age, sex, BMI, and height, and these data are presented in Table 1. To summarize, the 62 subjects in this study had normal BMI and a mean height of 163.38 ± 8.70 m and a mean weight of 58.96 ± 8.84 kg. Fat percentage ranged from 21.00% to 39.00% in women with an average of 32.33 ± 4.55% and from 20.00% to 25.99% in men with an average of 22.40 ± 3.82%. FVC of the study subjects had a value of >80% for 31% of females and 24% of males.

| Variable                              | Total (n) | Percentage (%) |
|---------------------------------------|-----------|----------------|
| Sex                                   |           |                |
| Women                                 | 34        | 54.8           |
| Men                                   | 28        | 45.2           |
| Age (years)                           |           |                |
| 20–29                                 | 48        | 77.4           |
| 30–39                                 | 14        | 22.6           |
| Body mass index (kg/m²)               |           |                |
| 18.50–20.99                           | 19        | 30.6           |
| 21.00–22.49                           | 21        | 33.9           |
| 22.50–23.99                           | 10        | 16.1           |
| 24.00–24.99                           | 12        | 19.4           |
| Body height (cm)                      |           |                |
| 149–159                               | 25        | 40.3           |
| 160–169                               | 19        | 30.7           |
| 170–179                               | 17        | 27.4           |
| 180–189                               | 1         | 1.6            |
| Body weight (kg)                      |           |                |
| 40.00–49.99                           | 9         | 14.5           |
| 50.00–59.99                           | 26        | 41.9           |
| 60.00–69.99                           | 20        | 32.3           |
| 70.00–79.99                           | 7         | 11.3           |
The fat percentages in our study were measured using the BIA method with SECA scales, the fat percentage distribution is shown in Table 2. Based on the results of the Pearson’s correlation test, p > 0.001 indicates no significant relationship between fat percentage and FVC (Table 3).

### Table 2. Fat percentage distribution of research subjects

| Fat category | Percentage in women (%) | Percentage in men (%) |
|--------------|-------------------------|-----------------------|
| Under        | 2.9                     | 0                     |
| Normal       | 88.2                    | 25.0                  |
| Over         | 8.8                     | 57.1                  |
| Obesity      | 0                       | 17.9                  |

### Table 3. Pearson’s correlation test result of fat percentage with forced vital capacity

| Variable                        | KVP (ml)       | P     |
|---------------------------------|----------------|-------|
| Fat percentage in women (%)     | 32.33 (+4.55)  | 0.120*|
| Fat percentage in men (%)       | 22.40 (+3.82)  | 0.680**|

*Mean (±standard deviation)

**Pearson’s correlation test

4. Discussion

Age and sex are factors that can affect fat percentage, whereas age, sex, BMI, height, and weight are factors that can affect the measured value of FVC.

The age of subjects in this study had a normal distribution with an average age of 26.32 ± 4.26 years and the majority (77%) were aged 20–29 years. According to WHO, individuals aged >19 years can be categorized as adults [6]. The mean age in this study was not much different from that of subjects in a previous study by Agarwal et al. in which the mean age was 27.85 ± 9.71 years [1]. Age affects the fat percentage and lung function, considering that visceral fat increases and muscle mass decreases with increasing age. In addition, lung function also declines with age because of the weakening of various respiratory muscles [7].

In addition, sex can affect both the fat percentage and the vital capacity of the lungs, and in this study, 54.8% (n = 34) of subjects were females and 45.2% (n = 28) were males. Studies conducted by Sutherland et al and Park et al. found differences in the relationship between body composition and lung function in women and men [4,8].

The average value of fat percentage in our group of women was 32.33 ± 4.55%, whereas males had considerably lower fat percentage scores, with a total of 57.1% (n = 16) males having fat percentages in the range of 20.00–25.99%, which is categorized as excess fat. Remarkably, a total of 25.0% (n = 7) had a fat content in the range of 8.00–19.99%, which is considered normal, and 17.95% (n = 5) males had a higher fat percentage of >25.00%.

This is similar to the results from the study by Park et al who found an average value of fat percentage of 22.3 ± 5.48% in men and 30.9 ± 5.46% in women [4]. Differences in the value of fat percentage in female and male group can be caused by essential fats in women being higher than in men. In addition, hyperandrogenism or high androgen hormones in women also increase the production of fats. These differences in men and women are also seen in how fats are stored. In women, fats are stored in the gluteal–femoral areas, whereas in men, these are generally stored in the visceral or abdominal areas, which also explains the higher risk of cardiovascular diseases in men than in women [5,9].
Overall, 88.2% (n = 30) of the women in our study had a fat percentage in the range of 21.00–33.99%, which is considered normal, whereas 8.8% (n = 3) had fat percentages in the range of 34.00–39.99%, which is considered excess fat, and 2.9% (n = 1) had a fat percentage of <21%.

In this study, the mean value of FVC across all subjects was 3220 ± 730 ml; it was 2739 ± 456 ml for females and 3804 ± 553 ml for males.

Although the results are almost the same, these lung capacity results are lower than those found in an earlier study by Park et al., which recorded an average value of 3,506 ± 810 ml across the entire group of subjects with normal weight, with an average of 2.940 ± 460 ml in women and 4.120 ± 630 ml in men [4].

This study found no significant relationship between fat percentage and FVC. In both the female and male groups, there was no significant correlation (p = 0.092 and p = 0.120, respectively).

These results are in considerable contrast to those of several studies that suggested a definite relationship between fat percentage and FVC. In particular, our results are not in accordance with those of Park et al. which reported a negative correlation between the fat percentage and FVC, being greater in males than in females [4]. Similar results were also found by Joshi et al. and Jeelani et al. who reported a negative correlation between fat percentage and FVC [10,11].

Furthermore, the study by Jung et al. also found similar results regarding a correlation between the fat percentage and FVC in men but not in women [12]. Such sex differences could be due to differences in the fat distribution between males and females. Fats accumulate in the gluteal–femoral region in women and in the abdomen in males. Visceral fat has a strong association with lung function impairment, which has a greater effect [13]. Jeelani et al.’s study found that fat distribution in the abdominal areas is associated with decreased lung function in males and that central fat may cause mechanical impairment of the lung [14]. Similarly, Hada et al. have shown that fat accumulation in the upper part of the body causes a decrease in the thoracic volume and a decrease in the respiratory muscle strength that it is necessary to move the chest [13].

In contrast, a study conducted by Agarwal et al. on 223 adults showed no significant correlation between fat content and FVC either in men or in women [1]. However, Lad et al. found that changes in the value of lung capacity varied with changes in the fat percentage and found a correlation between the fat percentage and FVC in both under and overweight individuals. According to Lad et al. in the overweight group, this change in the pulmonary vital capacity can be caused by expansional obstacles due to fat accumulation that blocks the movement of the chest and diaphragm, whereas in the underweight group, lung function may decrease because of a reduction in the lung muscle mass and strength caused by malnutrition [5].

5. Conclusions
The results of this study revealed no significant correlation between fat percentage and FVC in adults with normal BMI.

References
[1] Agarwal N, Hulke S M 2015 Correlation of body composition with pulmonary function in adults. Br. J. Med. Med. Res. 91
[2] Pasco J A, Holloway K L, Dobbins A G, Kotowicz M A, Williams L J, Brennan S L 2014 Body mass index and measures of body fat for defining obesity and underweight: a cross-sectional, population-based study. BMC Obes. 1
[3] Guzel D, Aydemir Y, Akdemir R, Erkorkmaz U 2016 Determination of the relationship between the body composition and pulmonary function in obese individuals. Eurasian Journal of Pulmonology 18 24
[4] Park J E, Chung J H, Lee K H, Shin K C 2012 The Effect of body composition on pulmonary function. Tuberc. Respir. Dis. 72 433
[5] Lad U P, Jaltade V G, Lad S S, Satyanarayana P 2012 Correlation between body mass index (BMI), body fat percentage and pulmonary functions in underweight, overweight and normal weight adolescents. *JCDR*. 6 350

[6] World Health Organization 2015 *World report on ageing and health*. (Geneva, Switzerland: World Health Organization)

[7] Karacan S, Güzel N A, Colakoglu F, Baltaci G 2008 Relationship between body composition and lung function in elderly men and women. *Adv. Ther.* 25 168

[8] Sutherland T J, McLachlan C R, Sears M R, Poulton R, Hancox R J 2016 The relationship between body fat and respiratory function in young adults *Eur. Respir. J.* 48 734

[9] Ajmani S, Anupama N, Nayatara A, Ganaraja B, Vishnu S, Pai S R 2012 Effect of abdominal fat on dynamic lung function tests. *International Journal of Biomedical and Advance Research* 3 632

[10] Joshi A R, Singh R, Joshi A R 2008 Correlation of pulmonary function tests with body fat percentage in young individuals. *Indian J. Physiol. Pharmacol.* 52 383

[11] Nuttall F Q 2015 Body mass index: obesity, BMI, and health: a critical review. *Nutr. Today* 50 117

[12] Jung D H, Shim J Y, Ahn H Y, Lee H R, Lee J H, Lee Y J 2010 Relationship of body composition and C-reactive protein with pulmonary function. *Respir. Med.* 104 1197

[13] Hada R, Chandel C S, Kanwar G, Shekhawat M, Vyas S, Chauhan N, Batra A 2015 A study of correlation of FEV1/FVC ratio with body fat percentage in young individuals. *Journal of Dental and Medical Sciences* 14 81

[14] Jeelani M, Ahmed M 2015 Pulmonary function test in relation to abdominal obesity in adult males in age group of 18-21 years in around raichur city. *Journal of Evidence Based Medicine and Healthcare* 2 2746