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Effect of waist circumference and body mass index on respiratory function

Gökhan Çoraplı [1], Mahmut Çoraplı [2]

[1] Adıyaman University, Department of Chest Diseases, Adıyaman, Turkey
[2] Haliç University Faculty of Medicine Hospital Avcılar Hospital, Radiology, Istanbul, Turkey

ORCID ID of the author(s)

GÇ: 0000-0002-3992-840X
MÇ: 0000-0002-4223-7845

Abstract

Background/Aim: The increase in waist circumference and obesity are among the important human health problems at present. It cannot be denied that this problem, which has a negative effect on many body systems, may also cause negative effects on the respiratory system. Therefore, we aimed to investigate the effect of waist circumference and body mass index (WC and BMI, respectively) on spirometric parameters, such as the forced expiratory volume in 1 s and forced vital capacity (FEV1 and FVC, respectively).

Methods: In this retrospective cohort study, patients who applied to the chest diseases outpatient clinic of our hospital between January 1 and December 31, 2022 and had existing abdominal computed tomography (CT) and pulmonary function test results recorded in the hospital system were included. The WC of the patients was measured using the abdominal CT results. The BMI of the patients was measured using their height and weight values. The correlation between the WC, BMI, and spirometric parameters (FEV1, FVC) was examined.

Results: A statistically significant correlation between the WC and BMI values of the 90 patients included in the study and their FVC and FEV1 values was found. In the relationship between all evaluated parameters, the *P*-value was <0.001. Based on the Spearman's correlation test, it was concluded that WC showed a highly negative correlation with both FVC and FEV1 (−0.984 and −0.870, respectively). BMI also had a high negative correlation with FVC and FEV1 (−0.905 and −0.867, respectively).

Conclusion: Weight gain, which leads to an increase in WC and BMI, appears to have a negative effect on the respiratory system. To maintain good respiratory function, it is recommended that patients adopt lifestyles that help them avoid gaining weight.

Keywords: waist circumference, body mass index, computed tomography, respiratory function test, spirometer

Corresponding Author
Gökhan Çoraplı
Adiyaman University, School of Medicine
Department of Chest Diseases, Adıyaman, Turkey
E-mail: gcorapli02@mail.com

Ethics Committee Approval
The study was approved by the ethics committee of Adıyaman University (Decision No: 2023/1-24, Decision Date: January 24, 2023).
All procedures in this study involving human participants were performed in accordance with the 1964 Helsinki Declaration and its later amendments.

Conflict of Interest
No conflict of interest was declared by the authors.

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Introduction

Respiratory function is measured using a spirometer, which measures pulmonary function. This test measures specific parameters, such as the forced vital capacity (FVC), forced expiratory volume in 1 s (FEV1), FEV1/FVC, forced mid-expiratory flow ($FEF_{25–75}$), and vital capacity (VC). The calculated values are then compared with reference values obtained from healthy individuals with the same demographic characteristics as the patient. These characteristics include gender, age, weight, height, and race. Pulmonary function test results may indicate whether the patient has obstructive, restrictive, or mixed type respiratory failure [1,2]. Obesity can be defined as hypertrophy and hyperplasia of fat storage cells or excessive fat storage. According to the World Health Organization, people with a body mass index (BMI) greater than 30 kg/m^2 are considered obese [3]. Apart from the BMI, obesity and adipose tissue can be measured with different techniques, which include computed tomography (CT) measurements of abdominal adipose tissue and manual measurement of the waist circumference (WC) [4,5].

Obesity has an impact on many systems in the human body; one of the most important systems that obesity affects is the respiratory system. Obesity and/or adipose tissue may have respiratory-related physiological and anatomical effects, such as an increase in workload and a decrease in lung volume [6,7]. It is also known that weight gain is associated with many respiratory diseases, including asthma, chronic obstructive pulmonary disease, obesity hypoventilation syndrome, and sleep apnea [8]. Aside from their effects on the respiratory system, studies proving the association of weight gain and/or obesity with early mortality in adults have been published [9,10]. Numerous studies have examined the effects of obesity on lung function. However, to the best of our knowledge, studies in which the WC measurements are based on CT results and the effect of such values on pulmonary function test results was determined are very limited in number. Thus, this study was conducted to contribute additional information to the few studies in the literature on the effects of CT-measured WC and BMI on the respiratory system.

Materials and methods

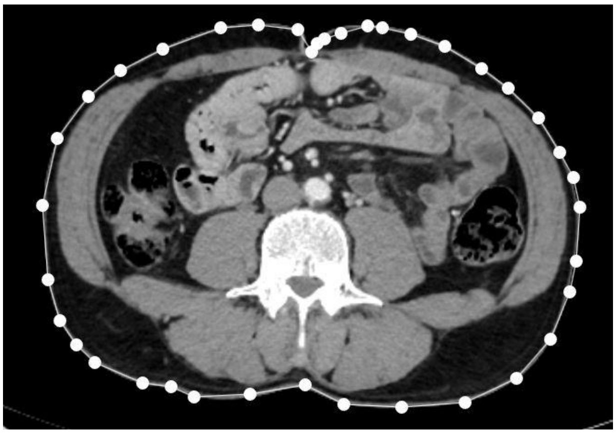
Sample group

This study was designed as a retrospective study with a retrospective cohort. In this study, patients who applied to the chest diseases outpatient clinic of our hospital between January 1 and December 31, 2022 and had both abdominal CT and pulmonary function test results recorded in the hospital system were included. As this study was a retrospective cohort study, it consisted of patients recruited using inclusion criteria without prior calculation of study size or power analysis. Inpatients were not included in the study. Patients who did not have appropriate abdominal CT scans were excluded from the study. Only patients who were over the age of 18 were included in the study. Patients who could not perform the pulmonary function test properly and/or patients with gross intra-abdominal pathology were excluded. Patients with structural and/or interstitial lung diseases or who smoked over 20 packs of cigarettes per year were also excluded. The patients included in the study were divided into two main subgroups: (1) obese and (2) normal groups. Obese patients' BMI and WC measurements were obtained, and the relationship between these two parameters and FVC and FEV1 spirometric parameters was investigated. To avoid potential biases, the radiologist who measured the WC performed the measurements without having any knowledge about the patients. Since BMI was obtained from the files of the patients and consisted of the records obtained before the study, bias did not occur. Ethics committee approval for the study was obtained from Adıyaman University Non-Interventional Clinical Research Ethics Committee (Decision Date: January 24, 2023, Decision No: 2023/1-24)

Imaging

The included patients were imaged using a 16-detector CT scanner (MX16, Philips Medical System, Koninklijke, Netherlands). The CT device parameters were 16 × 0.75 mm beam collimation, 0.75 s turn time, 1 mm slice thickness, 1 mm slice reconstruction, 90–120 kV tube voltage, and 50–110 mAs effective tube current. The abdominal circumference of the patients was measured by analyzing CT images using the Oracle Database program version 1.10.48.299. The abdominal CT images of these patients were evaluated by a radiologist with at least 10 years of experience (Figure 1). Patients who had improper abdominal CT images that prevented evaluation (artifacts, inappropriate image acquisition, and other issues) were not included in the study.

Figure 1: Axial abdomen computed tomography scan cross-section from umbilicus level for measuring waist circumference.



Statistical analysis

A normality test was used to applied to determine whether the variables were not normally distributed. Spearman's correlation analysis was used to determine the correlations between the non-normally distributed variables. Correlation coefficients of 0–0.30, 0.31–0.70, and 0.71–1 were considered low, moderate, and high, respectively [11]. P-value <0.05 was considered statistically significant. Statistical analysis of the data was performed using IBM SPSS Statistics for Windows 26.0 (IBM Corp., Armonk, NY, USA).

Results

The study included 90 patients of whom 56 (62%) were male, and 34 (37%) were female. The mean age of the obese patients was 48 years, mean WC was 103.70 mm, mean BMI was 33.04 kg/m^2, mean FVC was 73.24%, and mean FEV1 was 75.20% (Table 1).

Table 1: Demographic characteristics of the participants.

Variable	n	%
Groups		
Healthy	33	36.7
Obese	57	63.3
Gender		
Male	56	62.2
Female	34	37.8
	mean (SD)	
Age	48.00 (11.64)	
WC	103.70 (22.06)	
BMI	33.04 (8.75)	
FVC	73.24 (10.98)	
FEV1	75.20 (9.64)	

n: number of patients, SD: standard deviation

The correlation between WC and the FVC and FEV1 parameters was evaluated. A statistically significant, high, and negative correlation between WC and the lung parameters was found (*P*<0.001). The correlation between BMI and the same parameters was also evaluated. A significantly high and negative correlation between WC and the lung parameters was also found (*P*<0.001) as shown in Table 2.

Table 2: Correlation between WC and BMI and the lung parameters, FEV1 and FVC. respectively).

Variable	Value	WC
WC	s	1.000
	P-value	1.000
FVC	S	–0.984
	P-value	<0.001
FEV1	S	–0.870
	P-value	<0.001
Variable	**Value**	**BMI**
BMI	s	1.000
	P-value	1.000
FVC	s	–0.905
	P-value	<0.001
FEV1	S	–0.867
	P-value	<0.001

S: Spearman's correlation, *P*-value: Significance, WC: waist circumference, BMI: body mass index, FEV1: forced expiratory volume in 1 s, FVC: forced vital capacity

Discussion

This study is unique in that the correlation between the WC and BMI parameters of participants and their spirometry test parameters was based on CT scan results that were used to measure WC to acquire more accurate measurements. It was shown that WC and BMI showed highly negative correlations with FVC and FEV1.

In a study by Sutherland et al. [12] on the effect of BMI and WC on lung function in 361 participants, it was found that an increase in BMI and WC caused a significant decrease in the FVC and FEV1 parameters. In another similar study with a sample size of 80 participants, it was reported that an increase in BMI and WC had a negative effect on both FVC and FEV1 [8]. The present study demonstrated similar results. Although the small number of participants compared to the study by Sutherland et al. [12] is a limitation in our study, it is thought that the results of the present study are more specific than those in previous studies since WC measurements were based on CT images.

In a study by Thijs et al. [13], the volume of abdominal adipose tissue of 98 patients was measured using magnetic resonance imaging (MRI), and a volumetric increase in abdominal adipose tissue was found to lead to a significant decrease in the FVC and FEV1 parameters. Considering that the current study included a similar number of patients as their study did and obtained similar results despite using a different test method, the similarity in these findings further proves the relevance of this study.

In a study evaluating 94 patients who underwent surgery for weight reduction, the change in lung function before and after surgery was examined. The BMI, WC, FEV1, and FVC parameters of obese individuals with a BMI >37 kg/m^2 were examined three months after weight reduction surgery, and it was observed that a significant decrease in the BMI and WC of the patients led to significant increase in their FEV1 and FVC parameters [14]. In a similar study, 52 obese patients with obstructive sleep apnea underwent weight reduction surgery. When the pre- and post-operative lung functions of the patients were evaluated, a significant improvement was observed in the patients' FVC and FEV1 parameters [15]. The results of these two studies show that weight loss has a positive effect on lung function. Thus, the finding of the present study, in which participants with lower WC and BMI had better lung function, complements the results of these two previous studies. It is also noteworthy that the number of patients included in these two studies was about the same as the number of participants in our study.

In a study concerning obese patients with asthma and a high BMI, it was observed that weight gain impaired lung function, caused respiratory complaints, and negatively affected the FEV1 and FVC. However, the WC of the patients was not measured in that study [10]. In another similar study, the abdominal adipose tissue of asthmatic patients was volumetrically measured based on CT results. According to the results, the increase in volumetric abdominal adipose tissue led to an increase in the need for inhaled medication in asthmatic patients and led to a decrease in spirometric parameters, such as the FEV1 and FVC [16]. In a study conducted with chronic obstructive pulmonary disease (COPD) patients, who have characteristics similar to asthmatic patients, it was found that a volumetric increase in abdominal adipose tissue caused an increase in respiratory complaints and a significant decrease in parameters, such as the FEV1 and FVC [17]. Although only patients with asthma and COPD were evaluated in the three previously mentioned studies, their results were in line with the present study.

In a study by Ochs-Balcom et al. [18] in which the effect of CT-measured abdominal adipose tissue volume on lung function, was investigated, it was found that increased adipose tissue volume produced a significantly negative effect on the FEV1 and FVC of males, while it had no significant effect on the FEV1 and FVC parameters of females. In the current study, the results were the same for both genders. Therefore, while the results from their study regarding males were in line with our results, the result regarding females were different.

Limitations

Although this study was unique in terms of methodology, it was limited by the fact that it was conducted in a single center, only included a small patient population, and gender and age effects were excluded from evaluation. Researching the correlation between age and gender and the parameters that we evaluated in future studies will contribute new information to the literature. In addition, the results obtained by including the larger population and multiple centers will be more relevant.

Conclusion

Increasing WC and BMI due to weight gain and obesity, which are among the important problems of present-day human health, have a negative effect on many systems in the body. In this study we investigated the possible negative effects of obesity on the respiratory system. In this study, we revealed negative WC- and BMI-related respiratory system effects, such as causing a decrease in the FVC and FEV1 parameters, as measured in pulmonary function tests.

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