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# Age, gender, and pulmonary diseases in compliance with pulmonary function testing

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**Abstract**

Pulmonary function tests (PFTs) are critical tools for the diagnosis and monitoring of respiratory diseases. However, patient compliance with the test affects the reliability of the results. This study was designed to analyze factors such as age, gender, and the presence of cardiopulmonary diseases that influence compliance with PFTs. This retrospective study evaluated factors affecting PFT compliance in patients referred by a pulmonologist between April and September 2024. Demographic characteristics, including age, gender, and the presence of cardiopulmonary diseases, were analyzed using univariate and multivariate methods. Among the patients, 89.3% demonstrated compliance. Non-compliance was notably higher in older individuals. Female gender emerged as an independent risk factor for PFT non-compliance. Although chronic obstructive pulmonary disease (COPD) was linked to non-compliance in univariate analyses, it showed no independent effect in multivariate models. Conversely, patients with asthma exhibited better compliance. These findings highlight the need for tailored strategies to improve PFT compliance, especially for older adults, women, and patients with COPD. Implementing individualized support could enhance the reliability and diagnostic value of PFTs. Future research should explore additional psychosocial and behavioral factors to develop comprehensive interventions that address barriers to compliance.

**Keywords:** Age, asthma, chronic obstructive pulmonary disease, female gender, pulmonary function testing

## Introduction

Pulmonary function tests (PFTs) are fundamental diagnostic methods used to assess lung capacity and identify respiratory diseases [1]. Commonly referred to as spirometry, PFTs are among the first investigations performed in patients presenting with complaints of shortness of breath [2]. They are considered the gold standard for diagnosing chronic obstructive pulmonary disease (COPD), asthma, and other respiratory disorders [3]. Additionally, PFT results play a critical role in evaluating disease severity, determining treatment plans, and monitoring responses to therapy [4,5]. However, for PFTs to provide reliable and reproducible results, patients must fully comply with the test procedures. Considering the technical requirements of the procedure, this compliance may vary depending on the patient's physical, cognitive, and psychosocial capabilities.

The prevalence of respiratory diseases increases in the elderly population. Therefore, evaluating the relationship between PFT compliance and these conditions in such patients is of great importance. However, age is known to play a significant role in PFT compliance. Non-compliance may be more common in older individuals due to physical limitations, cognitive decline, and difficulties adapting to technical procedures [6]. This study aims to better understand the individual and disease-related factors influencing PFT compliance. Examining the effects of age, gender, and cardiopulmonary diseases on compliance can contribute to the development of strategies to enhance the effectiveness of these tests. The study seeks to provide a significant contribution to literature by assessing these relationships in a broad patient population.

## Material and Methods

This retrospective study was conducted on patients who received services at our hospital between April 1, 2024, and September 1, 2024. The research was initiated with the approval of the Ankara Atatürk Sanatorium Training and Research Hospital Clinical

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Research Ethics Committee on November 13, 2024 (approval number: 161) and was carried out in accordance with the ethical principles outlined in the Declaration of Helsinki.

All spirometry tests were performed in the same room using the same spirometer and pneumotachograph (Koko ist in Deutschland, ZAN®) connected to a computer for recording spirometry data. Data recorded for each test were analyzed individually with respect to flow-volume and volume-time curves, as well as traditional spirometric variables.

Spirometry tests were conducted in accordance with the technical standards recommended by international guidelines. The interpretation and quality assessment of the spirometry tests were performed by two certified pulmonologists with expertise in spirometry.

### Patient Selection

The PFTs used in this study were randomly selected from all eligible tests conducted at our hospital within the specified timeframe, without specific selection criteria.

### Inclusion Criteria

- Age between 18 and 80 years,
- Patients referred to for PFT by a pulmonologist for any reason.

### Exclusion Criteria

- Patients under 18 years of age,
- Patients aged 80 years and above,
- Patients with active respiratory tract infection symptoms,
- Patients diagnosed with a COPD exacerbation,
- Patients diagnosed with an asthma exacerbation,
- Pregnant patients,
- Patients diagnosed with dementia,
- Patients with neuromuscular diseases,
- Patients with a diagnosis of neurological disorders,
- Patients with uncontrolled heart failure,
- Patients with untreated or uncorrected hearing impairments.

### Evaluation of PFT Compliance

A test was considered non-compliant if any of the following criteria were not met [7]:

- The test must begin promptly,
- Maneuvers must be performed completely during the test,
- The patient must not cough during the test,
- The test must not be terminated prematurely,
- The effort level must remain consistent,
- The transition time from end inspiration to expiration must be ≤2 seconds,
- The time to reach peak flow from total lung capacity must be ≤1.5 seconds,
- After inspiration, the pause at total lung capacity must be less than or equal to 2 seconds,
- Exhalation must be performed for a sufficient duration, with a plateau formed at the end of exhalation and no volume change (<0.025 L) for at least 1 second.

### Analysis of the Impact of Comorbidities on Spirometry Quality

In order to statistically evaluate the impact of comorbidities on spirometry quality, diseases were categorized into two groups based on the most affected organ system: cardiovascular diseases and chronic lung diseases. Since some patients had multiple types of comorbidities, they were included in more than one group.

### Statistical Analysis

The statistical analysis of the data was performed using IBM SPSS 27.0 statistical software. Descriptive statistics were used for data analysis; continuous variables were presented as mean±standard deviation, and categorical variables were presented as numbers and percentages (%). Differences between two groups were assessed using the independent samples t-test or Mann-Whitney U test for continuous variables and the chi-square test or Fisher's exact test for categorical variables. To evaluate the relationships between the characteristics of patients compliant and non-compliant with pulmonary function tests, univariate logistic regression analysis was first conducted, followed by multivariate logistic regression analysis to control the effects of independent variables. Results from the regression models were reported as hazard ratios (HR) with 95% confidence intervals (CI). A significant level of $p<0.05$ was considered for all statistical analyses.

## Results

A total of 942 patients were included in the study. The mean age was 53.77 years. Of the patients, 53% were female. The demographic characteristics of the patients included in the study are summarized in Table 1.

**Table 1.** Demographic characteristics of the study population

| Variable | All patients (N=942) (100%) N (%), Mean±SD |
|---|---|
| **Age (years)** | 53.77±14.09 |
| **Gender** | |
| **Male** | 443 (47) |
| **Female** | 499 (53) |
| **Body mass index (kg/m²)** | 28.23±5.88 |
| **Comorbidities** | 742 (78.7) |
| **COPD*** | 211 (22.4) |
| **Asthma** | 321 (34.1) |
| **Interstitial lung disease** | 42 (4.5) |
| **Coronary artery disease** | 136 (14.4) |
| **Heart failure** | 19 (2%) |

*Chronic obstructive pulmonary disease

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Table 2 summarizes the PFT results of the patients included in the study. It was observed that 89.3% of the patients complied with the pulmonary function test.

**Table 2.** Pulmonary function test characteristics of the study population

| Variable | All patients N=942 (100%) N (%), Mean±SD |
|---|---|
| **Compliance with pulmonary function test** | 841 (89.3) |
| **$FEV_1$* %** | 77.37±20.73 |
| **$FEV_1$ (L)** | 2.36±0.89 |
| **FVC %** | 77.54±17.99 |
| **FVC (L)** | 2.97±1.04 |
| **$FEV_1$/FVC (%)** | 80±21.38 |

*$FEV_1$: forced expiratory volume in 1 second, FVC: forced vital capacity

Figure 1 presents a histogram showing the distribution of $FEV_1$ values among the study participants.

Figure 2 presents a histogram showing the distribution of FVC values among the study participants.

Figure 3 presents a histogram showing the distribution of $FEV_1$/FVC values among the study participants.

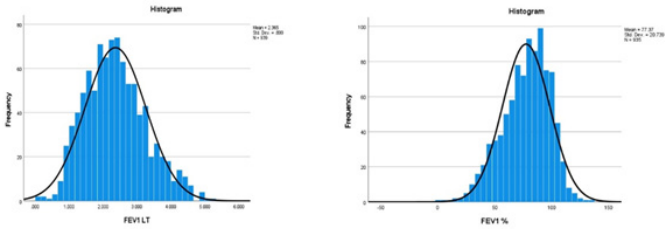


**Figure 1.** $FEV_1$ Histogram

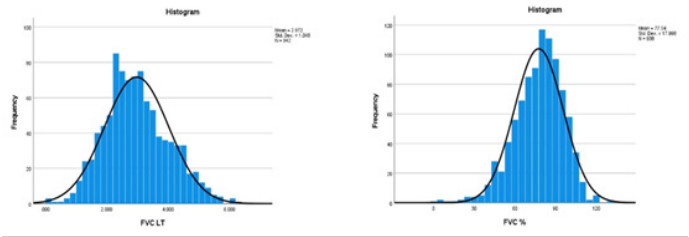


**Figure 2.** FVC Histogram

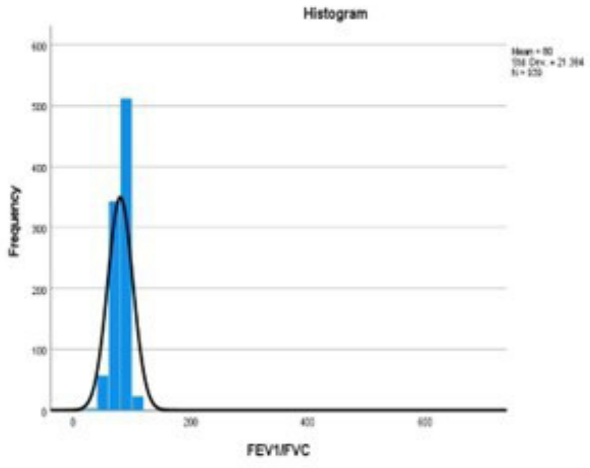


**Figure 3.** $FEV_1$/FVC Histogram

Table 3 compares the clinical characteristics of patients compliant and non-compliant with PFTs. The mean age of non-compliant patients (60.98±13.42 years) was significantly higher than that of compliant patients (52.90±13.92 years) ($p<0.001$). In terms of gender distribution, female patients were more prevalent in the non-compliant group (62.4%) ($p=0.043$).

**Table 3.** Clinical characteristics affecting pulmonary function test compliance

| Characteristic | Compliant patients (N=841, 89.3%) Mean±SD | Non-Compliant Patients (N=101, 10.7%) Mean±SD | p value* |
|---|---|---|---|
| **Age (years)** | 52.90±13.92 | 60.98±13.42 | <0.001 |
| **Gender** | | | |
| **Female** | 436 (51.8%) | 63 (62.4%) | 0.043 |
| **Male** | 405 (48.2%) | 38 (37.6%) | |
| **Body mass index (kg/m²)** | 28.18±5.85 | 28.65±6.10 | 0.392 |
| **Presence of comorbidities** | 662 (78.7%) | 80 (80%) | 0.766 |
| **COPD**** | 177 (21%) | 34 (33.7%) | 0.004 |
| **Asthma** | 296 (35.2%) | 25 (24.8%) | 0.036 |
| **Interstitial lung disease** | 38 (4.5%) | 4 (4%) | 0.797 |
| **Coronary artery disease** | 116 (13.8%) | 20 (19.8%) | 0.105 |
| **Heart failure** | 16 (1.9%) | 3 (3%) | 0.471 |

*Statistical significance set at $p<0.05$, **chronic obstructive pulmonary disease

Table 4 presents the results of the logistic regression analysis conducted to evaluate the factors affecting compliance with pulmonary function tests.

In the univariate analysis, age (HR: 1.048, 95% CI: 1.030–1.067, $p<0.001$), female gender (HR: 1.540, 95% CI: 1.007–2.355, $p=0.046$), and COPD (HR: 1.904, 95% CI: 1.220–2.970,

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p=0.005) were identified as factors increasing the risk of non-compliance with PFTs. Conversely, asthma patients were observed to have better compliance with PFTs (HR: 0.605, 95% CI: 0.377–0.971, p=0.037).

According to the results of the multivariate analysis, age (HR: 1.047, 95% CI: 1.027–1.066, p<0.001) and female gender (HR: 2.252, 95% CI: 1.400–3.624, p<0.001) were identified as independent factors influencing non-compliance with PFTs. The effect of COPD lost its significance in the multivariate analysis (p=0.197). It was also clearly demonstrated that asthma patients exhibited better compliance with PFTs in the multivariate analysis (HR: 0.583, 95% CI: 0.341–0.998, p=0.049).

**Table 4.** Logistic regression analysis for evaluating non-compliance with pulmonary function tests

| Variable | Univariate logistic regression | | Multivariate logistic regression | |
|---|---|---|---|---|
| | HR (95% CI) | p value* | HR (95% CI) | p value* |
| **Age** | 1.048 (1.030-1.067) | <0.001 | 1.047 (1.027-1.066) | <0.001 |
| **Female gender** | 1.540 (1.007-2.355) | 0.046 | 2.252 (1.400-3.624) | <0.001 |
| **COPD**** | 1.904 (1.220-2.970) | 0.005 | 1.414 (0.836-2.391) | 0.197 |
| **Asthma** | 0.605 (0.377-0.971) | 0.037 | 0.583 (0.341-0.998) | 0.049 |

*Statistical significance set at p<0.05, **chronic obstructive pulmonary disease

## Discussion

For PFTs to yield reliable results, it is crucial that patients fully comply with the testing procedure. However, individual factors can influence this compliance, leading to higher rates of non-compliance in certain groups. In this study, cardiopulmonary diseases, age, and gender were evaluated as factors affecting PFT compliance. Among a total of 942 patients analyzed, the majority (89.3%) were observed to comply with the PFTs. Our findings indicate that age, female gender, and COPD may negatively affect PFT compliance, whereas asthma patients exhibit better adherence. These results emphasize the need to develop patient group-specific strategies to enhance the reliability of PFTs. Future studies should be designed to incorporate psychosocial and cognitive factors, providing more comprehensive approaches to improving PFT compliance.

Elderly individuals may face challenges in understanding the steps of spirometry testing, coordinating the required performance, and exerting the necessary physical and cognitive effort to obtain reliable measurements [8]. This can be attributed to increased physical limitations, cognitive decline, or difficulty adapting to the technical requirements of PFTs as age progresses. However, the prevalence of respiratory diseases also increases in the elderly population. Respiratory symptoms such as cough and shortness of breath can be associated with non-respiratory comorbidities like heart disease, muscle weakness, and anemia [9]. These conditions may lead to misinterpretation of patient status. Therefore, this population needs to be specifically addressed.

In our study, it was shown that non-compliance with PFTs was significantly higher among elderly individuals. Similarly, a study by Melo et al. indicated that most elderly individuals could achieve satisfactory results with repeated testing [10]. Therefore, additional interventions may be required to improve compliance in this patient group.

With the growing recognition of gender-specific risk factors in healthcare, studies have shown that women experience more difficulty adhering to technical procedures compared to men [11]. In line with this, our study identified female gender as an independent risk factor for non-compliance with PFTs. The literature also indicates higher rates of non-compliance with PFT maneuvers among women [12]. The challenges women face in adhering to the technical requirements of PFTs may be influenced by multidimensional factors, such as psychosocial issues and differences in individual motivation. However, prospective studies are needed to validate these findings and better understand the underlying causes. In this context, developing individualized strategies to enhance women's compliance with technical procedures emerges as an important necessity.

COPD stands out as a significant public health issue due to its high prevalence and the substantial use of healthcare resources [13]. Spirometry is the standard diagnostic method used to identify airflow limitation, the primary physiological feature of COPD [14]. Additionally, it plays a critical role in assessing treatment response and the long-term monitoring of the disease [15]. The literature has shown that pharmacotherapy initiated through early treatment and intervention can reduce COPD exacerbations and hospital admission rates, while significantly improving patients' quality of life [16,17]. In this context, the early diagnosis of COPD and the rapid initiation of appropriate treatment approaches are of great importance. A study by Kim et al. examining the rates of spirometry use in COPD patients reported an increase in the number of spirometry tests requested over follow-up years, alongside a corresponding rise in inhaler prescriptions [18]. The researchers emphasized the fundamental role of spirometry in disease management based on these findings. In light of this information, our study evaluated the relationship between COPD and compliance with spirometry testing. In univariate analysis, COPD was shown to be associated with non-compliance with spirometry. However, in multivariate

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analysis, COPD did not exhibit an independent effect on this relationship. This finding highlights the need to consider the influence of other factors, such as age and gender. In conclusion, a more comprehensive evaluation of factors contributing to non-compliance with spirometry is a critical step toward addressing these challenges effectively.

Asthma, as a chronic airway disease, requires regular monitoring and treatment. In this condition, PFT is an indispensable tool for diagnosis, treatment planning, and monitoring disease progression. In our study, it was observed that asthma patients exhibited better compliance with PFT compared to other patient groups. This finding can be attributed to the fact that asthma patients are typically under regular medical follow-up and are more familiar with PFT procedures. In the study by Doğru et al., it was noted that asthma patients demonstrated high levels of compliance with PFT, which was considered an important advantage facilitating early diagnosis and monitoring processes in this patient group. Additionally, prior spirometry experience was emphasized as one of the most significant parameters influencing adherence to test protocols [19]. In this context, the prior experiences of asthma patients may serve as a key factor enhancing their compliance with PFT.

### Limitations

This study provides a comprehensive analysis of factors affecting PFT compliance in a large patient population. However, the study has certain limitations. For instance, the high compliance rate among the patient group may have restricted a detailed evaluation of factors associated with non-compliance. Considering that the histogram data for $FEV_1/FVC$ ratios largely concentrated within a specific range, with an average of 80, it appears that the patient group primarily consisted of individuals who could be evaluated within normal limits. This may have influenced the results of our analysis and limited the generalizability of the findings. It should also be noted that PFT compliance might vary depending on the person administering the test. The fact that our study was conducted in a tertiary referral pulmonology hospital with experienced staff in PFT likely contributed to the high compliance levels observed. Additionally, the exclusion of important parameters such as psychosocial factors and patient motivation from the study scope prevented a broader perspective on the findings. Therefore, future studies that consider these factors could provide a more detailed assessment of their effects on PFT compliance and offer a more comprehensive understanding of the subject.

## Conclusion

This study found that factors such as age and female gender pose risks for non-compliance with PFTs, whereas certain groups, such as asthma patients, demonstrated better compliance. These findings highlight the importance of considering individual differences to enhance the effectiveness of pulmonary function tests and improve patient compliance. Future studies should be designed to include more diverse patient populations and psychosocial factors for a broader understanding.

**Conflict of Interests**
*The authors declare that there is no conflict of interest in the study.*

**Financial Disclosure**
*The authors declare that they have received no financial support for the study.*

**Ethical Approval**
*Ethical approval was obtained from the Clinical Research Ethics Committee of Ankara Ataturk Sanatorium Training and Research Hospital (decision date: November 13, 2024 (approval number: 161).*

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