

## Lung Function Capacities in Obstructive Sleep Apnea Syndrome

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### Abstract

**Background and Objective:** Previous studies have reported abnormal changes in spirometric parameters and flow-volume curves in patients with obstructive sleep apnea syndrome (OSAS) during sleep. This study aimed to evaluate the lung function capacities and flow-volume curves in these patients.

**Materials and Methods:** This was a cross-sectional study. A total of 120 adults aged 18-65 years with suspected OSAS were selected. A full record of demographic characteristics and history of chronic diseases, as well as the results of spirometry and polysomnography were obtained. Spirometric indices and flow-volume curves in OSAS patients and normal subjects were compared.

**Results:** The mean body mass index was  $30.85 \pm 6.18$  kg/m<sup>2</sup>. Average neck and abdominal circumferences were  $41.68 \pm 3.53$  and  $108.56 \pm 14.34$  (cm); respectively. The subjects were divided into three groups based on their AHI. The sawtooth signal was observed in a flow-volume curve in 20.2% and 2.8% of patients with and without OSAS; respectively. Significant differences were seen in sawtooth appearance signs and forced expiratory flow (FEF) 50/forced inspiratory flow (FIF) 50 ( $P > 0.001$ ), but these parameters were not significantly different in AHI subgroups of sleep apnea.

**Conclusion:** Sawtooth sign and  $FEF50/FIF50 \geq 1$  could be useful in diagnosis of OSAS, although it cannot be used to predict the severity. Despite a significant difference in a sawtooth sign and  $FEF50/FIF50$  between OSAS patients and normal subjects, no significant differences in lung functions were observed between OSAS patients and normal subjects.

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**Keywords:** Spirometry; Obstructive sleep apnea syndrome; Polysomnography

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### Introduction

Obstructive sleep apnea syndrome (OSAS) is defined as excessive and unexplained sleepiness during the day with more than 5 obstructive breathing events (apnea or hypopnea) during 1 hour of sleep. Apnea in adults is defined as stop of breathing for more than 10 seconds, while a 50% decrease of baseline ventilation during sleep for more than 10 seconds with 4% saturated oxy-

gen in arterial blood ( $SpO_2$ ) reduction, or awakening (arousal) is defined as hypopnea (1).

OSAS pathophysiology is due to respiratory arrest secondary to upper airway collapse during sleep (1, 2). Severe forms of this syndrome are found in 4% of men and 2% of women; while milder forms of OSAS (at least 5 apneas per an hour) are found in 27% of men and 9% of women with no risk factor for OSAS (1). Two major common risk factors associated with OSAS are age and weight; however, obesity is the most

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common risk factor for OSAS (3, 4).

OSAS patients usually have signs and symptoms during sleep and awake. Signs and symptoms during sleep include respiratory symptoms, choking and waking in panic, shortness of breath, restlessness, enuresis, reflux, drooling, and sweating. Daily signs and symptoms include excessive drowsiness, fatigue, morning headache, loss of concentration, personality changes, loss of skills, loss of attention, and depression (4, 5).

Detrimental complications of OSAS include hypertension, cardiovascular, cerebrovascular, and kidney diseases, type 2 diabetes, pulmonary hypertension, and sudden death (6, 7).

Sawtooth pattern is defined as regular oscillations at constant intervals occurring on the forced expiratory or forced inspiratory flow-volume curve, and is supposed to reflect fluttering of upper airway tissue (8, 9). Flow-volume curve in spirometry is a screening test of choice to rule out obstructive lung diseases (10). Flow-volume curves display airflow as it relates to lung volume during maximum inspiration and expiration. It shows the appropriateness of airflow for a specific lung volume. Flow oscillations usually seen on flow-volume curves, defined as a sawtooth sign, seem to be because of collapsible obstructed upper airway and may be used for diagnosis of an upper airway disorder (11).

Haponik et al. reported that 44% of patients with OSAS had forced expiratory flow (FEF) 50/forced inspiratory flow (FIF) 50 > 1, while it was observed for only 8% of people without OSAS (12). Sanders et al. showed that 85% of people with OSAS show sawtooth pattern, whereas it is not seen in people without OSAS (13). Shore et al. concluded that sawtooth pattern had 92% specificity in the diagnosis of OSAS (14).

Sawtooth sign in Krieger et al., study was seen in 61% of patients with symptomatic obstructive sleep apnea and 46% of patients without obstructive sleep apnea. In 67% of patients with OSAS, the FEF50/FIF50 was more than 1; however, this was 71% in patients without OSAS (15). Hoffstein et al. showed that 12% of patients with OSAS had FEF50/FIF50  $\geq$  1, while this ratio was 14% in people without OSAS (16).

Katz et al. concluded that flow-volume curve is not a good screening test for the diagnosis of OSAS in patients with snoring during sleep (17). Amado et al. concluded that the forced expiratory volume 1 second (FEV)<sub>1</sub>, forced vital capacity (FVC), FEV<sub>1</sub>/FVC, FEF50, FIF50, and PEF indi-

ces have no significant differences in patients with OSAS and normal subjects (18). Campbell et al. showed that no significant difference between flow-volume curve in patients with OSAS and non-OSAS exists (19).

Hoffstein and Oliver study demonstrated that flow-volume curve, plethysmography, and carbon monoxide diffusion capacity are equal in patients with OSAS in different grades of AHI (20). Ozturk et al. concluded that there is no significant association between FEF25-75/FVC and the level of airway obstruction, i.e., airway obstruction was seen only in severe OSAS patients (21).

Ashraf et al. also concluded that abnormal changes in spirometry of subjects with obstructive sleep apnea are uncommonly without diagnosed chronic lung disease and are not very common (22).

Sharma et al. found that FEV<sub>1</sub> could not be a proper criterion for prediction of increased risk of OSAS, and there is no relationship between FEV<sub>1</sub> percent, apnea-hypopnea index (AHI), and oxygen desaturation index (ODI) (23).

Identification of patients, who are prone to sleep apnea, is extremely valuable to clinical medicine. Accordingly, among a pile of different methods invented, spirometry is one with no sufficient evaluation. Therefore, this study aimed to evaluate the diagnostic value of spirometry in the diagnosis of patients with obstructive sleep apnea.

## Materials and Methods

This cross-sectional study was conducted in Shahid Rahnamoun Hospital from April 2013 to July 2014 in Yazd, Iran. The sample size of 120 was calculated based on the previous studies; however, 120 adults (age over 18 years) finally were selected through convenience sampling method. The population included was people with a suspected clinical history of sleep apnea based on the medical history, and who underwent polysomnography. Convenience sampling method was performed from the pool of eligible subjects until the sample size was completed. Convenience sampling is one of the main types of a non-probability sampling methods, which subjects are selected based on their convenient accessibility.

Inclusion criteria included adult patients (over 18 and below 65 years of age) with suspected sleep apnea based on clinical history and an informed consent to perform polysomnography and spirometry. Exclusion criteria included a history of asthma, chronic obstructive pulmonary diseases

(COPD), or any other chronic lung diseases, recent smokers, patients with neurological disorders, airways' tumor, parkinsonism, and heart failure.

For all patients, a researcher-made questionnaire was completed, which included demographic characteristics, history of heart disease, lung disease, and type 2 diabetes mellitus. Patients with heart failure, COPD, asthma and other chronic lung diseases, recent smoking, and patients with neurological disorders were excluded.

For all patients, spirometry (Datpspir\_120 spirometer, Sibelmed, Spain) was performed. It was performed in sitting position (a standard position for spirometry), and in accordance with the standards of European Respiratory Society/American Thoracic Society (ERS/ATS). To measure lung volumes by spirometry device, the person was asked to put a nose clip and put the mouthpiece in the mouth, and after a very deep inspiration, perform a rapid expiration with maximum intensity. For each person, at least three acceptable maneuvers with ERS/ATS repeatability standards were performed (24).

Then for all patients, polysomnography test (by ALICE®5 DIAGNOSTIC SLEEP SYSTEM (Respironics, USA) was done. In this test, the patient was hospitalized overnight in a hospital sleep laboratory, and polysomnography was performed for minimum of 8 hours (25). If AHI was 5 or higher, OSAS would be considered, and if AHI was < 5, the subject would be considered as normal. The OSAS patients were divided into two groups based on their AHI: Mild-to-moderate OSAS ( $5 \leq \text{AHI} < 30$ ), and severe OSAS ( $\text{AHI} \geq 30$ ).

The data analysis was performed using SPSS

software (version 20, IBM Corporation, Armonk, NY, USA). For comparison of quantitative variables Independent sample t-test and ANOVA were used. The level of significance was set at 0.05. Then, the spirometric indices and flow-volume curve in patients and normal subjects were compared, and the association of these indices with severity of AHI was evaluated.

**Ethical considerations:** All subjects were given a complete description on how to perform spirometry and polysomnography and written informed consent was obtained from all subjects. The subjects were assured of confidentiality of all the information and data.

## Results

Totally, 120 patients with suspected obstructive sleep apnea were attended based on clinical history. The mean age of the subjects was  $48.23 \pm 10.60$  years with a range of 27-79 years. 37 subjects (30.8%) were female.

The mean of body mass index was  $30.85 \pm 6.18$  ( $\text{kg/m}^2$ ) with a range of 19.53-57.16. The mean of neck circumference was  $41.68 \pm 3.53$  (cm) with a range of 32-50 (cm). The mean of abdominal circumference was  $108.56 \pm 14.34$ , ranging from 81 to 178.

Following polysomnography, the subjects were divided into three groups based on their AHI: 36 were normal ( $\text{AHI} < 5$ ), 36 were in mild-to-moderate group ( $5 \leq \text{AHI} < 30$ ), and 48 subjects in severe group ( $\text{AHI} \geq 30$ ). The sawtooth signal was observed in a flow-volume curve in 20.2% and 2.8% of patients with and without OSAS; respectively. The detailed data are shown in tables 1-3.

**Table 1.** Mean ( $\pm$ SD) of SpO<sub>2</sub>, desaturation index, Snoring duration, sawtooth sign, and upper airways' obstruction parameter ( $\text{FEF}_{50}/\text{FIF}_{50} \geq 1$ ) in normal subjects and patients with sleep apnea

Variable	AHI				P-value
	Normal (n = 36)	Mild-to-moderate (n = 36)	Severe (n = 48)	Total (n = 120)	
SpO <sub>2</sub> (%)	93.52 (3.03)	89.66 (5.12)	89.79 (5.08)	90.87 (4.86)	0.001
Oxygen desaturation index (ODI)	11.15 (7.29)	22.23 (19.15)	41.81 (23.59)	27.64 (22.54)	0.001
Snoring duration (Second)	13.08 (11.05)	31.85 (22.72)	37.94 (19.68)	28.66 (21.25)	0.001
Sawtooth sign					
Yes	-	6 (16.7)	11 (22.9)	17 (20.2)	0.588
No	-	30 (83.3)	37 (77.1)	67 (79.8)	
$\text{FEF}_{50}/\text{FIF}_{50} \geq 1$					
Yes	-	12 (33.3)	11 (22.9)	23 (27.4)	0.329
No	-	24 (66.7)	37 (77.1)	61 (72.6)	

Statistical test: ANOVA; Statistical test: Fisher's exact test; AHI: Apnea-hypopnea index; Normal:  $\text{AHI} < 5$ ; Mild-to-moderate:  $5 \leq \text{AHI} < 30$ ; Severe:  $\text{AHI} \geq 30$ ; SpO<sub>2</sub>: Saturated oxygen in arterial blood;  $\text{FEF}_{50}/\text{FIF}_{50}$ : Forced expiratory flow 50/ forced vital capacity 50  $\geq 1$ ; SD: Standard deviation

**Table 2.** Mean ( $\pm$ SD) of FEV<sub>1</sub> (%), FVC (%), FEV<sub>1</sub>/FVC, FEF25-75 (%), Sawtooth sign, and upper airways' obstruction parameter (FEF50/FIF50  $\geq$  1) in normal subjects and patients with sleep apnea

Item	AHI		P-value
	n = 36 (normal)	n = 84 (sleep apnea)	
FEV <sub>1</sub> (%)	97.05 (15.19)	102.65 (18.92)	0.119
FVC (%)	91.88 (11.86)	88.25 (15.05)	0.198
FEV <sub>1</sub> /FVC	86.17 (5.13)	88.09 (11.02)	0.342
FEF25-75 (%)	108.13 (13.42)	138.13 (41.30)	<0.001
Sawtooth sign			
Yes	1 (2.8)	17 (20.2)	0.012
No	35 (97.2)	67 (79.8)	
FEF50/FIF50 $\geq$ 1			
Yes	2 (5.6)	23 (27.4)	0.007
No	34 (94.4)	61 (72.6)	

Statistical test: t test; AHI: Apnea-Hypopnea Index; FEV<sub>1</sub>: Forced expiratory volume in 1 second, FVC: Forced vital capacity; FEF25-75: Forced expiratory flow between 25% and 75% of the forced vital capacity; FEF50/FIF50  $\geq$  1; SD: Standard deviation

Based on table 1, a significant correlation was observed between the percentage of SpO<sub>2</sub>, desaturation index, snoring duration, and severity of AHI considering ANOVA test.

**Table 3.** Mean ( $\pm$ SD) of FEV<sub>1</sub> (%), FVC (%), FEV<sub>1</sub>/FVC, and FEF25-75 (%) depending on the severity of obstructive sleep apnea

Variable	AHI		P-value
	Mild-to-moderate (n = 36)	Severe (n = 48)	
FEV <sub>1</sub> (%)	105.03 (18.96)	100.89 (18.89)	0.322
FVC (%)	91.86 (14.87)	85.54 (14.57)	0.056
FEV <sub>1</sub> /FVC	89.21 (3.93)	87.10 (14.18)	0.390
FEF25-75 (%)	135.22 (37.91)	140.31 (43.93)	0.579

Statistical test: t test; AHI: Apnea-hypopnea index; FEV<sub>1</sub>: Forced expiratory volume in 1 second; FVC: Forced vital capacity; FEF25-75: Forced expiratory flow between 25% and 75% of the forced vital capacity; SD: Standard deviation

Table 1 summarizes that sawtooth sign was seen in 16.7% and 22.9% in the flow-volume curve of patients with mild-to-moderate and severe obstructive sleep apnea; respectively; however, there was no significant relationship between the severity of OSAS and sawtooth sign. As can be seen from table 1, 3.33% of patients with mild-to-moderate sleep apnea and 22.9% of patients with severe OSAS had FEF50/FIF50  $>$  1, despite no significant correlation between the severity of sleep apnea and upper airway obstruction parameters (FEF50/FIF50  $\geq$  1).

According to table 2, a significant difference between two groups (normal subjects and patients with obstructive sleep apnea) in mean of FEF25-75% was observed, with no significant differences between other spirometry parameters.

The sawtooth sign was observed in the flow-volume curve of 20.2% of patients with OSAS.

While this sign was seen only in 2.8% of patients without OSAS, there was a significant association between OSAS and sawtooth sign.

As table 2 shows, 27.4% of people with OSAS, had upper airway obstruction parameter (FEF50/FIF50  $\geq$  1), while it was observed in 5.6% of normal subjects, and there was a significant relationship between OSAS and upper airway obstruction parameter.

A significant difference between the mean of FEV<sub>1</sub> percent, FVC percent, FEV<sub>1</sub>/FVC, FEF25-75%, and severity of sleep apnea (based on AHI) did not exist (Table 3).

## Discussion

We showed that there were no significant differences in terms of lung functions between patients with OSAS and normal subjects, despite significant differences in sawtooth sign and FEF50/FIF50 between patients and normal subjects.

OSAS is one of the health problems associated with severe complications such as hypertension, ischemic heart disease, pulmonary artery pressure, cardiac arrhythmia, stroke, and sudden death (26). Patients with OSAS have different structural and functional disorders in the upper airways, which could impair the lung function tests. Spirometry is performed extremely common due to respiratory problems in these patients.

Since polysomnography is the current method of diagnosis for these patients and this test is relatively expensive and time consuming, this study was aimed to evaluate pulmonary function capacity and flow-volume curve of these patients to determine the usefulness of this method in diagnosis of OSAS. Although spirometry is in sitting posi-

tion, and polysomnography is in non-sitting position, since our diagnosis is not based on the patient position we could interpret the spirometry findings in association with polysomnography.

These abnormal changes include sawtooth sign and increases of  $FEF50/FIF50 \geq 1$ . The sawtooth sign was observed in flow-volume curve in 20.2% and 2.8% patients with and without OSAS; respectively. Sawtooth sign could be useful in the diagnosis of patients with OSAS, although it could not be used to predict the severity of OSAS.

In this study, 27.4% of patients with OSAS had  $FEF50/FIF50 \geq 1$ , while only 6.5% of patients without OSAS had that. Therefore,  $FEF50/FIF50$  equal or more than 1 can be useful in diagnosis of OSAS, though it cannot be used to predict the severity of it.

Other spirometric indices (FEV1%, FVC%, and FEV1/FVC) in patients with OSAS were in the normal expected range and were not significantly different from normal people. It seems that OSAS does not affect the pulmonary function capacities.

Sharma et al., in line with the present study showed that the percentage of FEV1 could not be used as a criterion for prediction of increased risk of OSAS, and the relationship between the percentage of FEV1, AHI, and ODI does not exist (23).

Ashraf et al. concluded that abnormal changes in spirometry of patients with OSAS are not very common. Sawtooth sign was seen in only 3.12% of flow-volume curves in these patients (22). This study is not consistent with the present study. In Ashraf study, all the subjects had OSAS during sleep, while in this study, spirometry of healthy subjects and patients with OSAS were compared (22).

In another study, which was in line with our study was performed by Ozturk et al., who showed no significant relationship between  $FEF25-75/FVC$  and airway obstruction (21). Hoffstein and Oliver found that the flow-volume curve, plethysmography, and diffusion capacity of carbon monoxide in patients with different intensities of OSAS were similar (20). In the present study, the mean percentage of FEV1, FVC, and FEV1/FVC in patients with mild-to-moderate OSAS and those with severe OSAS were not significantly different.

In the Krieger et al. study, sawtooth sign was found in 61% of patients with OSAS and 46% of patients without OSAS. In 67% of patients with OSAS,  $FEF50/FIF50$  is more than 1, while this proportion was found in 71% of patients without OSAS (15). In the present study, the sawtooth

sign was also observed in 12% of patients with OSAS and only 2.8% of non-OSAS patients. Nearly 27.4% of patients with OSAS had  $FEF50/FIF50$  more than 1, while only 6.5% of normal subjects had this (20). Levent et al. showed that there is not any association between spirometry in patients with OSAS and sawtooth sign (9).

## Conclusion

There were no significant differences in lung functions between patients with OSAS and normal subjects, but there were significant differences in sawtooth sign and  $FEF50/FIF50$  between patients and normal subjects. These parameters were not significantly different in subtypes of sleep apnea (based on AHI). It appears as though these may be helpful in the diagnosis of OSAS, but the severity of OSAS is not predictive. More research is recommended to explore the association of spirometry parameters and sleep apnea.

## Conflict of Interests

Authors have no conflict of interests.

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