

## The Hidden Features of Breathing

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### Abstract

**Purpose:** Humans have two types of breathing pattern, abdominal and thoracic, which show physiological differences. The primary goal of the present study is to assess the spirometric variability of breathing patterns in individuals, and secondary goal is to elucidate the influence of age and gender differences on breathing types.

**Methods:** Patients aged between 18 and 40 years were asked to participate in the study, and spirometry using the Spirodoc® (MIR-Medical International Research-Srl, Roma, Italy) was preoperatively performed on subjects. Age, gender, weight, height, body-mass index, the American Society of Anesthesiologists score, the observed breathing pattern (thoracic or abdominal) while standing, and the spirometric measurements were recorded into a standardized data sheet.

**Results:** A total of 126 subjects were included in the study. The mean age of the patients was  $29.90 \pm 6.76$ , and the mean body-mass index value was  $26.20 \pm 5.84$ . Sixty-seven subjects were female and 59 were male. The forced expiratory time value of spirometry was found to be significantly higher in patients with abdominal breathing ( $5.94 \pm 1.01$ ) compared to thoracic ( $4.47 \pm 1.32$ ;  $p=0.007$ ). The Forced inspiratory vital capacity measurement in patients with abdominal breathing pattern ( $4.26 \pm 1.01$ ) was higher than in thoracic ( $3.61 \pm 1.04$ ;  $p=0.063$ ). The thoracic breathing pattern was observed at a rate of 84.7% ( $n=50$ ) among subjects of the 18-29-year age group, and 73.8% ( $n=45$ ) in subjects of the 30-40-year age group ( $p=0.139$ ).

**Conclusion:** The present study revealed that abdominal breathing is superior in some aspects of spirometric measurements compared to thoracic breathing.

**Keywords:** Spirometry; Breathing; Abdominal wall; Thoracic wall; Vital capacity; Abdominal breathing; Thoracic breathing

### Introduction

Undoubtedly, one of the critical life-support systems of the body is the respiratory system. The respiratory system is composed of various mechanical structures including the lungs, thoracic wall and diaphragm, in the abdominal rib cage compartment. The main function of this system is the "breathing" which provides gas exchange with the environment through the continual muscle action of the thoracic wall [1]. According to the current knowledge, the two basic patterns of breathing are diaphragmatic (abdominal) and thoracic. Thoracic breathing is defined as the filling of the middle and upper portion of the lungs, whereas diaphragmatic breathing is described as inflating all three parts of the lungs including the lower parts, which is considered to be the most efficient due to the increased amount of blood to receive oxygen. A third pattern, clavicular breathing, is defined as pulling up the clavicles or collar bones to raise the intake of air [2,3]. Furthermore, chest and abdominal wall mobility is a significant factor in the evaluation of respiratory functional status. Breathing pattern and thoracic/abdominal wall motion can be affected by various factors including an individual's position, age, gender, respiratory overload, neuromuscular diseases, increased airway resistance, and chronic obstructive pulmonary disease [3-6]. The loss of any wall mobility may

be a predictor of forthcoming respiratory complication [7]. It is reported that there is less abdominal movement observed in females compared to males [8].

Spirometry is the most useful technique to obtain quantitative measurements of lung volume and flow, thus allowing comparable results among individuals. It is a physiological test that evaluates an individual's inhaled and exhaled volumes of air. The outcome of spirometry, which has well-validated normal values, is very effective and accurate in diagnosing and monitoring upper and lower airway disorders. In this context, we hypothesized that thoracic and abdominal breathing patterns may reveal significant differences in spirometric measurements.

Therefore, the primary goal of the present study is to assess the spirometric variability of breathing patterns in individuals, and the secondary goal is to elucidate the influence of age and gender differences on breathing types.

### Materials and Methods

After approval of Gaziosmanpaşa University Clinical Trials Ethics Committee (14-KAEK-194), this prospective study was conducted from 2014 to 2015. Patients aged between 18 and 40 years with an American Society of Anesthesiologists score (ASA) of I or II, who were admitted to the outpatient unit of the Department of Anesthesiology,

Medical Faculty, Gaziosmanpasa University for preoperative assessment to undergo elective surgery requiring general anesthesia, were invited to participate in the study. The following parameters were the exclusion criteria: patients scheduled for ear-nose-throat surgery, cardiovascular surgery, or those with an upper airway pathology (eg: maxillofacial fractures and tumors), a history of head/neck surgery or maxillofacial surgery, obstructive or restrictive pulmonary disease, and a history of smoking (tobacco and tobacco products). In the outpatient unit, spirometry using the Spirodoc® (MIR-Medical International Research-Srl, Roma, Italy) was preoperatively performed on subjects, after obtaining written informed consent. The age, gender, weight, height, body-mass index (BMI), the ASA score, the observed breathing type (thoracic or abdominal) while standing, and the measurements (FVC (Forced Vital Capacity), FEV<sub>1</sub> (Forced Expiratory Volume in 1<sup>st</sup> second), FEV<sub>3</sub> (Forced Expiratory Volume in 3 seconds), FEV<sub>6</sub> (Forced Expiratory Volume in 6 seconds), FEV<sub>1</sub>/FVC, FEV<sub>3</sub>/FVC, PEF (Peak Expiratory Flow), FEF<sub>25</sub> (Forced Expiratory Flow 25%), FEF<sub>50</sub> (Forced Expiratory Flow 50%), FEF<sub>75</sub> (Forced Expiratory Flow 75%), FEF<sub>25/75</sub>, FET (Forced Expiratory Time), FIVC (Forced Inspiratory Vital Capacity), FIV<sub>1</sub> (Forced Inspiratory Volume in 1<sup>st</sup> second), FIV<sub>1</sub>/FVC and PIF (Peak Inspiratory Flow)) belonging to all subjects were recorded into a standardized data sheet. All variables were dichotomized in terms of thoracic or abdominal breathing pattern.

### Statistical analysis

Normality and variance were tested using the one-Sample Kolmogorov-Smirnov test for each variable. Quantitative data were presented as means and standard deviation, and qualitative data as frequency and percentage. Associations were performed by using the Spearman's correlation coefficient (ρ). The comparisons were carried out by using the Mann-Whitney U test. Analyses were completed by using the Statistical Package for the Social Sciences (SPSS Inc., Chicago, IL) version 20.0 program. The statistical significance for all analyses was set at P<0.05.

### Results

A total of 126 subjects were included in the study. Demographical data is presented in Table 1.

	Thoracic Breathing	Abdominal Breathing	p
Age (years)	29.33 ± 6.72	31.16 ± 7.13	0.252
Gender (F/M)	51/44	11//14	0.389
Height (cm)	167.57 ± 8.75	168.36 ± 14.98	0.175
Weight (kg)	73.31 ± 14.26	72.56 ± 17.46	0.936
BMI (kg/m2)	26.14 ± 5.19	26.13 ± 8.35	0.665

F: Female; M: Male; BMI: Body Mass Index.  
Mann-Whitney U test.

**Table 1:** Demographic characteristics.

The mean age of the patients was 29.90 ± 6.76, and the mean BMI value was 26.20 ± 5.84. Sixty-seven subjects were female and 59 were male. A total of 51 (82.3%) females and 44 (75.9%) males had thoracic breathing. The relationship between breathing pattern and spirometric outcomes is displayed in a correlation matrix (Table 2).

	Thoracic/Abdominal breathing pattern	
	P	P
FVC	0.104	0.258
FEV <sub>1</sub>	0.117	0.203
FEV <sub>3</sub>	0.098	0.287
FEV <sub>6</sub>	0.108	0.242
FEV <sub>3</sub> /FVC	-0.134	0.145
FEV <sub>1</sub> /FEV <sub>6</sub>	-0.019	0.837
FEV <sub>1</sub> /FVC	-0.025	0.785
PEF	0.132	0.149
FEF <sub>25</sub>	0.11	0.232
FEF <sub>50</sub>	0.135	0.14
FEF <sub>75</sub>	0.062	0.5
FEF <sub>25/75</sub>	0.117	0.203
FET	0.249*	0.006*
FIVC	0.246	0.063
FIV <sub>1</sub>	0.171	0.2
FIV <sub>1</sub> /FIVC	-0.131	0.326
PIF	0.056	0.681

FVC, Forced Vital Capacity; FEV<sub>1</sub>, Forced Expiratory Volume in 1<sup>st</sup> second; FEV<sub>3</sub>, Forced Expiratory Volume in 3 seconds; FEV<sub>6</sub>, Forced Expiratory Flow in 6 seconds; PEF, Peak Expiratory Flow, FEF<sub>25</sub>, Forced Expiratory Flow 25%; FEF<sub>50</sub>, Forced Expiratory Flow 50%; FEF<sub>75</sub>, Forced Expiratory Flow 75%; FET, Forced Expiratory Time; FIVC, Forced Inspiratory Vital Capacity; FIV<sub>1</sub>, Forced Inspiratory Volume in 1st second; PIF, Peak Inspiratory Flow.  
Spearman's correlation analysis. \*p<0.05

**Table 2:** Correlation matrix.

The FET value of spirometry was found significantly higher in patients with abdominal breathing (5.94 ± 1.01) compared to thoracic (4.47 ± 1.32; p=0.007; Table 3). The FIVC measurement in patients with abdominal breathing pattern (4.26 ± 1.01) was higher than in thoracic (3.61 ± 1.04; p=0.063). The thoracic breathing pattern was observed at a rate of 84.7% (n=50) among subjects of the 18-29 year age group, and 73.8% (n=45) in subjects of the 30-40-year age group (p=0.139).

	Thoracic Breathing	Abdominal Breathing	p
FVC	3.92 ± 0.96	4.38 ± 0.96	0.257
FEV <sub>1</sub>	3.14 ± 0.74	3.53 ± 0.87	0.202
FEV <sub>3</sub>	3.79 ± 0.91	4.21 ± 0.91	0.285
FEV <sub>6</sub>	3.90 ± 0.96	4.37 ± 0.95	0.241
FEV <sub>3</sub> /FVC	96.90 ± 3.62	96.27 ± 2.27	0.144
FEV <sub>1</sub> /FEV <sub>6</sub>	80.93 ± 6.72	80.27 ± 6.96	0.836

<b>FEV<sub>1</sub>/FVC</b>	80.69 ± 7.06	80.02 ± 6.90	0.784
<b>PEF</b>	5.22 ± 1.58	6.05 ± 2.12	0.149
<b>FEF<sub>25</sub></b>	4.92 ± 1.42	5.67 ± 1.99	0.231
<b>FEF<sub>50</sub></b>	3.61 ± 0.96	4.30 ± 1.56	0.14
<b>FEF<sub>75</sub></b>	1.60 ± 0.59	1.77 ± 0.72	0.497
<b>FEF<sub>25/75</sub></b>	3.35 ± 0.94	3.78 ± 1.27	0.202
<b>FET</b>	4.47 ± 1.32	5.94 ± 1.01	0.007*
<b>FIVC</b>	3.61 ± 1.04	4.26 ± 1.01	0.063
<b>FIV<sub>1</sub></b>	2.93 ± 1.15	3.45 ± 1.20	0.198
<b>FIV<sub>1</sub>/FIVC</b>	82.01 ± 21.17	79.34 ± 15.20	0.322
<b>PIF</b>	3.00 ± 1.05	3.39 ± 1.52	0.678

FVC, Forced Vital Capacity; FEV<sub>1</sub>, Forced Expiratory Volume in 1st second; FEV<sub>3</sub>, Forced Expiratory Volume in 3 seconds; FEV<sub>6</sub>, Forced Expiratory Flow in 6 seconds; PEF, Peak Expiratory Flow, FEF<sub>25</sub>, Forced Expiratory Flow 25%; FEF<sub>50</sub>, Forced Expiratory Flow 50%; FEF<sub>75</sub>, Forced Expiratory Flow 75%; FET, Forced Expiratory Time; FIVC, Forced Inspiratory Vital Capacity; FIV<sub>1</sub>, Forced Inspiratory Volume in 1<sup>st</sup> second; PIF, Peak Inspiratory Flow.  
Mann-Whitney U test. \*p<0.05

**Table 3:** Comparison of spirometric measurements.

## Discussion

The present study showed that the forced expiratory time is longer in abdominal breathing, and also the forced inspiratory vital capacity has a tendency to be higher in patients with the abdominal breathing pattern. In addition, advanced age leads to a slight shift from thoracic to abdominal breathing. Abdominal breathing, which has been described as the typical adult breathing pattern, has a respiration rate of 12 to 20 times per minute with a physiological sinus arrhythmia, and also includes shallow thoracic movements. The tidal volume generally ranges between 750 and 2000 ml per inhalation. Abdominal breathing depends on the rhythmic diaphragm movements, upwards during exhalation and downwards during inhalation [9,10]. It also has a longer exhalation pause time leading to a prolonged expiration phase. Abdominal breathing is defined as effortless breathing [11], whereas, thoracic breathing is a tendency to breathe using the upper chest structures of the rib cage, including pectoral muscles, scalene muscles, and trapezius muscles. The diaphragm is pulled up during inspiration and down during expiration. Therefore, thoracic breathing may lead to dyspnea, fatigue, irritation, headaches, and increased feelings of anxiety. Prolonged thoracic breathing can cause lower O<sub>2</sub> levels in the blood [10].

Abdominal breathing has been shown as useful in the treatment of various health disorders including asthma, sympathetic activation, anxiety, panic attacks, hyperventilation, and the discomfort of menopause-related hot flashes, while also increasing endurance and physical performance [10]. Abdominal breathing is a teachable and learnable technique by verbal instructions, role modeling and limitation. Tibbets et al. showed that teaching slow abdominal breathing to asthmatic adults led to an increase in inhalation volume, decreased thoracic muscle use, diminished administration of medical therapy for asthma, and fewer emergency room visits and breathless episodes. The authors also reported that the improvements remained

over 16 months [12]. In addition, breath training is considered a beneficial treatment modality for dyspnea, chronic obstructive pulmonary disease, and hypertension; however there has been little clinical data on the benefits of teaching abdominal breathing to adults or children [13,14]. Gender differences may be seen in breathing pattern. Abdominal breathing pattern is more common in males. Females have a wider rib cage and minimal abdominal support to generate tidal volume compared to males during quiet breathing [15,16]. Recently, Kaneko et al. reported that females show more thoracic motions with less abdominal contributions than male subjects in the supine position. They also indicated that thoracic movement decreased with age [8]. Similarly, Verschakelen et al. demonstrated that males over 50 years of age showed less movement with their rib cages [3]. The present study revealed that a higher percentage of both females and males had thoracic breathing; however, females had a greater tendency toward thoracic breathing than males, and we also showed that abdominal breathing pattern with advanced age increased at a rate of 10% compared to thoracic, which was consistent with the outcomes of previous studies mentioned above.

Moreover, spirometry has been a widely used method to evaluate the pulmonary functions of an individual. Forced expiratory time is one of the components of outcomes obtained from spirometry. A recent study by Tsai et al., on a population of 37 normal and 65 obstructive patients, found that longer forced expiratory time was associated with higher forced vital capacity and first second forced expiratory volume [17]. In addition, forced vital capacity was dependent on expiratory time [18]. The present study showed that forced expiratory time is shorter in subjects with thoracic breathing; however, forced inspiratory vital capacity instead of the associated parameter, forced vital capacity, displayed a significant correlation with forced expiratory time. Forced inspiratory vital capacity is defined as the maximal volume of gas that can be inhaled during a forced and complete inspiration from a position of full expiration. It is closely associated with FEV<sub>1</sub>, the volume of air inhaled in one second during the performance of the forced inspiratory vital capacity [19]. In this context, the amount of inhaled volume of air may lead to longer exhalation times during spirometry. This study showed that FIVC and FEV<sub>1</sub> comparisons of the individuals in have a tendency to be higher in abdominal breathing compared to thoracic breathing. It can be suggested that abdominal breathing may provide a higher volume of air intake compared to thoracic breathing, leading to a time difference during expiration. The chief muscle of inspiration during abdominal breathing is the diaphragm. Individuals with thoracic breathing show less diaphragm movement. Indeed, diaphragm paralysis leads to mild to severe restrictive findings on pulmonary function tests. The forced expiratory volume in one second (FEV<sub>1</sub>) is decreased approximately 70% of predicted values in unilateral paralysis and 50% of predicted values in bilateral paralysis. The forced vital capacity is lowered to 75% of predicted, in unilateral paralysis and 45% of predicted, in bilateral paralysis [20]. In relation, abdominal breathing mostly associated with the diaphragm movement holds most of the functions of lungs and have significant effects on pulmonary volumes and flows.

The present study has several limitations. First, our results are limited by the relatively small sample size. Therefore, definitive results such as how demographic factors might influence spirometric measurements must await further studies with a larger population. Second, most subjects performed a maximum of three loops, hence no interpretation can be made on subsequent trends in the performance of spirometric measurements. Third, the age groups of the study

consisted of young adults, which restricts the application of results to other settings and patient populations.

In conclusion, this is the first study presented on the quantitative differences between abdominal and thoracic breathing in the English literature. It revealed that abdominal breathing, which can be learned and used to cope with various significant breathing disorders in adults, is superior in some aspects of spirometric measurements compared to thoracic breathing. The findings of the present study suggest that the abdominal breathing pattern is efficient in terms of inhalation, and increased age leads to a tendency toward the abdominal breathing type. However, further studies demonstrating the increase in tissue oxygenation by improving preoperative pulmonary functions in patients to undergo elective operations are required.

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