Evaluation of Spirometric Values in Healthy Population Referred to Spirometry Centers in Hamedan City, Iran

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Abstract

Background: Spirometry procedure is known to be an efficient test for evaluating lung function. Nevertheless, the ventilatory function indexes acquired by spirometry seem to have been affected by several factors, some of which are demographic and anthropometric parameters. Hence, our study aimed to address the effect of some specific features of Hamedani individuals in Iran on spirometric characteristics.

Methods: We assessed the spirometric parameters, including Forced Vital Capacity (FVC), forced expiratory volume in the first second (FEV1), maximal mid-expiratory flow rate (FEF25-75), and FEV1/FVC ratio, obtained from normal spirometry test of 1483 individuals between the ages of 16 and 89 years.

Results: FVC, FEV1, FEV1/FVC ratio, and FEF25-75 were different between the two genders significantly ($p<0.001$). Even though there was a higher FVC, FEV1, and FEF25-75 in males, FEV1/FVC ratios for males were significantly lower than the ratios for females at the same ages (total mean of 82.09±6.78 in males versus 84.94±6.49 for females). In addition, FEV1/FVC ratio and FEF25-75 were not significantly different between tall males and females with a height of >170 *cm*. Finally, age and stature influenced the ventilatory function values with a correlation strength of <0.001.

Conclusion: Albeit men, mostly because of their particular anatomic and physiologic feature of respiratory muscles, had larger FVC and FEV1, those who were tall showed no significant change in FEV1/FVC ratio and FEF25-75, in comparison with females. Irrespective of their height, men found a higher FEF25-75 as well.

Keywords: Adolescent, Forced expiratory volume, Iran, Lung, Spirometry, Vital capacity

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Introduction

The assessment of lung function is known to have a prognostic role in the diagnosis of respiratory abnormalities, which might vulnerably cause the sufferers to be affected by chronic lung diseases or even mortality in the short or long term as well (1). A well-established method for the functional evaluation of respiratory system is spirometry (2,3). Estimations of Forced Vital Capacity (FVC), forced expiratory volume in the first second (FEV1), Peak Expiratory Flow Rate (PEFR), maximal mid-expiratory Flow Rate (FEF25-75), Peak Inspiratory Flow Rate (PIFR), and FEV1/FVC and FEV1/PEFR ratios are required for the diagnosis and management of pulmonary abnormalities. More importantly, spirometry provides information on breathing reserve and exercise tolerance, too (4).

As shown in many studies, spirometric parameters vary in such features as age, gender, weight, height, lifestyle, environmental condition, socio-economic status, altitude, and ethnicity (5-8). To demonstrate, in a study conducted on 172 healthy men and 235 healthy women aged between 20 and 70, Jové *et al* showed that there was a linear decline in FVC and FEV1 with age for both genders. Thus, it is recommended that a reference value be determined in each nation or ethnic group by evaluating pulmonary function in their people without any respiratory deficit (9,10).

Similarly, it is important to determine the reference values for spirometric-related indexes in Iran where we have people of different ethnic groups living in different climates and altitudes. In this regard, there are few available studies performed in Iran (11-13). To be specific, a study performed by Golshan and Nemat-Bakhsh (11) identified that spirometric-prediction equations for Isfahani adults are as much applicable as those for American and European adults, but estimated a slightly higher lung volume. Another study on 1,499 Mazandaranies, living in the north of Iran, found the European Respiratory Society standard to be usable for spirometric predictors in the dwellers of Mazandaran (12).

Given this background, our study has been set to assess the aforementioned spirometric parameters in a healthy population in another region of Iran, called Hamedan, with their specific environmental condition and ethnicity, regarding age, gender factors, height, weight, and BMI.

Materials and Methods

Study population

Spirometric data collected from 1483 individuals with normal results, who had been referred to spirometry centers situated in the city of Hamedan, and also to Shahid Beheshti medical educational center, were used in this cross-sectional retrospective study. We excluded the subjects with Chronic Obstructive Pulmonary Disease (COPD), asthma, emphysema, neuro-muscular disease, cardiac or thoracic surgery, or any other history of respiratory illness.

Implementation of spirometry

To acquire pulmonary function-related spirometric indexes, a breath spirometer (Spirolab III) was utilized. The spirometry procedure was implemented according to the standard through which two spirometry curves were constructed according to the established acceptability and reproducibility criteria in ATS and BSPT. FVC (defined as a combination of three lung volumes including Tidal Volume (TV), Expiratory Reserve Volume (ERV) and Inspiratory Reserve Volume (IRV) was measured, thereby estimating FEV1, FEF25-75, and FEV1/FVC ratio. A cutoff value of >80% for both FEV1 and FVC and that of >0.7 for FEV1/FVC were then deemed as normality levels in our study.

Statistical analysis

SPSS (version 16.0) was utilized to evaluate the statistically obtained spirometric parameters and demographic data. Initially, Shapiro-Wilk and Kolmogorov-Smirnov tests were performed to check the normality and homogeneity of the data. Spirometric, as well as anthropometric variables, were expressed as descriptive statistics (mean±standard deviation). The significance of differences between means was tested by an independent t-test.

We took advantage of linear regression analysis by presenting the direction and degree of correlation for age, gender, weight, height, and BMI with ventilatory function characteristics obtained by the spirometer used in our study. In each step, one anthropometric variable was excluded through backward analysis. A P-value lower than 0.05 was considered a significant level.

Results

Of all included individuals consisting of 1277 (86.1%) male and 206 (13.9%) female, the mean age was 34.11±8.97 (range, 16-89) years. Anthropometric and demographic characteristics including age, weight (in *kg*), height (in *cm*), as well as Body Mass Index (BMI) (in kg/m^2), and spirometry-related parameters (FVC, FEV1, FEV1/FVC ratio, and FEF25-75) have been presented in table 1.

Respectively, 205, 803, and 69 Males versus 84, 110, and 12 females aged 15 to 29, 30 to 50, and over 50 were grouped into three age categories. While it was found that the total lung function variables (FVC, FEV1, FEV1/FVC ratio, and FEF25-75) between two genders were significantly different ($p<0.001$), men of all three age categories showed a higher FVC, FEV1and FEF25-75, when compared to females in the same ages (Table 2). However, the total mean accounting for FEV1/FVC ratio significantly decreased in males (82.09±6.78) in comparison with females (84.94±6.49). Interestingly, this trend was observed in all age groups. Additionally, table 2 indicated that there were contractions of ventilatory function indexes in both sexes with the advancing age. Subdividing the subjects into two groups with a height of ≤170 *cm* and >170 *cm* adjusted for age,

Table 1. Baseline characteristics and lung function variables

	Mean±SD	Min	Max		Mean±SD	95% CI	
						Lower limited	Upper limited
Age (years)	34.11±8.97	16	89	FVC	4.78±0.93	4.73	4.83
Weight (*kg*)	74.43±13.44	40	122	FEV_1	3.94±0.76	3.90	4.04
Height (*cm*)	173.44±8.35	126	195	FEV_1/FVC	82.66±5.75	53.30	82.77
BMI (kg/m^2)	24.82±3.87	15.88	40.70	FEF_{25-75}	4.09±1.05	1.39	8.80

SD: Standard deviation; FVC: Forced vital capacity; FEV_1: Forced expiratory volume in the first second; FEF 25-75: Expiratory flow from 25-75% of FVC

Table 2. Mean differences of ventilatory function indexes according to gender and age

	Age (years)	Male		Female		p-value
		Mean ± SD	95% CI	Mean ± SD	95% CI	
FVC	15-29	5.24±0.76	5.16-5.31	3.79±0.60	3.66-3.92	
	30-50	4.91±0.77	4.86-4.97	3.53±0.76	3.39-3.68	
	Over 50	4.18±0.59	4.04-4.33	2.47±0.37	2.23-2.70	
	Total	4.98±0.80	4.39-5.02	3.58±0.74	3.48-3.68	<0.001
FEV_1	15-29	4.36±0.62	4.30-4.42	3.23±0.40	3.14-3.31	
	30-50	4.02±0.65	3.97-4.06	2.97±0.58	2.86-3.08	
	Over 50	3.32±0.45	3.20-3.43	2.05±0.28	1.87-2.23	
	Total	4.09±0.67	4.05-4.13	3.02±0.56	2.95-3.10	<0.001
FEV_1/FVC	15-29	83.32±6.81	82.65-84.0	86.03±5.59	84.82-87.25	
	30-50	81.78±6.24	81.34-82.21	84.77±5.26	83.76-85.77	
	Over 50	78.50±10.33	75.96-81.04	78.86±14.94	69.37-88.35	
	Total	82.09±6.78	81.72-82.47	84.94±6.49	84.04-85.84	<0.001
FEF_{25-75}	15-29	4.57±1.04	4.46-4.67	3.77±0.79	3.60-3.94	
	30-50	4.09±1.0	4.02-4.16	3.39±0.87	3.22-3.55	
	Over 50	3.22±0.76	3.03-4.31	2.33±0.64	1.93-2.74	
	Total	4.19±1.05	4.14-4.25	3.48±0.89	3.36-3.60	<0.001

SD: Standard deviation; FVC: Forced vital capacity; FEV1: Forced expiratory volume in the first second; FEF 25-75: Expiratory flow from 25-75% of FVC

Table 3. Mean differences of ventilatory function indexes according to gender and height

Height	Ventilatory function indexes	Male Mean ± SD	Female Mean ± SD	p-value
≤170 *cm*	FVC	4.39±0.72	3.60±0.57	<0.001
	FEV_1	3.62±0.62	2.94±0.48	<0.001
	FEV_1/FVC	82.73±5.60	85.17±5.91	<0.001
	FEF_{25-75}	3.83±0.97	3.37±0.81	<0.001
>170 *cm*	FVC	5.17±0.73	4.58±1.21	<0.001
	FEV_1	4.28±0.61	3.73±0.76	<0.001
	FEV_1/FVC	82.14±5.67	83.76±4.76	0.194
	FEF_{25-75}	4.32±1.03	4.36±1.06	0.867

SD: Standard deviation; FVC: Forced vital capacity; FEV1: Forced expiratory volume in the first second; FEF25-75: Expiratory flow from 25-75% of FVC

Table 4. Regression analysis to determine the relationship between spirometric and Anthropometric features

Variables		Age	Height (*cm*)
FVC	r^2 (p-value)	0.175(<0.001)	0.659 (<0.001)
FEV_1	r^2 (p-value)	0.251(<0.001)	0.659 (<0.001)
FEV_1/FVC	r^2 (p-value)	0.242(<0.001)	0.659 (<0.001)
FEF_{25-75}	r^2 (p-value)	0.292(<0.001)	0.659 (<0.001)

r2: correlation coefficient; FVC: Forced vital capacity; FEV1: Forced expiratory volume in the first second; FEF25-75: Expiratory flow from 25-75% of FVC

the values obtained through spirometry showed significant differences between men and women (p<0.001), but the FEV1/FVC ratio (82.14±5.67 for males versus 83.76±4.76 for females; p=0.194), as well as FEF25-75 (4.32±1.03 for males versus 4.36±1.06for females; p=0.867) in the individuals with a height over 170 *cm*, represented no significant differences. Additionally, table 3 showed that there were contractions of ventilatory function indexes in both genders with the height.

As it can be observed from table 4, backward regression analysis depicted a strong inverse relationship between age and each spirometric parameter with r2 of -0.175, -0.251, -0.242, and -0.292 in terms of FVC, FEV1, FEV1/FVC ratio, and FEF25-75, respectively. In addition, height found a significant correlation strength of 0.659, 0.540, 0.313 (p<0.001) with FVC, FEV1, and FEF25-75, respectively. Nevertheless, there was a strong positive association between height and FEV1/FVC ratio (r2, -0.176; p<0.001). Conversely, gender factor, weight, and BMI showed no statistically significant correlation with the lung function values.

Discussion

Pulmonary function tests are all important to early diagnosis and manage respiratory abnormalities. Determining ventilatory function characteristics through spirometry procedure is very effective in this regard. With that, comes a controversy over the effect of some factors on the result acquired by the spirometer device, some of which are mentioned to be age, gender, weight, height, lifestyle, environmental condition, socioeconomic status, altitude, and ethnicity. Thus, it is mandatory to determine the reference spirometric values for different groups of people with various qualities of life, environmental condition, ethnics, *etc.* Concerning the necessity, we studied the spirometric results in healthy residents in Hamedan city, Iran.

Our data revealed an abrupt increase in the values of FVC, FEV1, and FEF25-75 in males compared to those in females. Possibly, this finding is associated with a difference in the properties of respiratory muscles due to different kinds of jobs in which they have always been involved in. This trend in terms of FEV1/FVC ratio was vice versa, as there was a higher ratio for females. The mentioned finding was consistent with the result found in the study conducted by Saleem *et al* (14) , through which they tested the pulmonary function of 3080 normal healthy non-smoking residents of Kashmir valley located in Asia next to Iran. However, the mean FVC (4.98±0.80 for men versus 3.58±0.74 for women) in the healthy people included in our study was higher than those obtained from research data from Kashmir valley (4.3±0.8 for men versus 3.0±0.5 for women) (14), Kurdistan (4.33±0.89 for men versus 3±0.46 for women) (13), and Sari (4.59 ± 0.73 for men versus 3.22 ± 0.54 for women) provinces (12) in Iran. It is also clear from this evidence that the values of the Iranian people are higher than those of the people in Kashmir.

More importantly, the mean FVC in the current study was higher than the mean FVC of 3.96±0.86, 4.20±0.87, 3.98±0.88, and 4.18±0.84, respectively, reported by the European Respiratory Society (ERS), International Thoracic Society (ITS), Morris, and Knudson. The evidence cited is the FVC result obtained based on American Thoracic Society (ATS)/ ERS standards by studying 407 healthy individuals from Argentina, which was lower than the one acquired in our study (7).

Additionally, our FEV1 result showed the same trend as FVC, while larger than the values in the people in Kashmir, Kurdistan, and Sari as well. While we found mean FEV1 of 4.09±0.67 for males, 3.90±0.63, 3.74±0.82, and 3.9±0.7 were found, respectively, in the literature (12-14). For females, it was also 3.02±0.56 against 2.80±0.49, 2.61±0.53, and 2.6±0.5. The FEV1 in the literature (7) was lower than ours. Similarity, ERS, ITS, Morris, and Knudson standards presented a lower FEV1 in comparison with ours. As per some evidence in the confirmation of the fact that the people living at relatively high altitudes to those near sea level have an increase in their lung volumes (15,16), our observation in terms of FVC and FEV1 in comparison with those observed for the individuals living in Sari maybe since Hamedan is situated at a higher altitude.

In both males and females, FEV1/FVC ratios in our study (males, 82.09±6.78; females, 84.94±6.49) found a decline, compared to FEV1/FVC ratios estimated in the study on the residents in Kashmir (males, 89.8±3.0; females, 87.6±3.2) (14).

Surprisingly, FEF25-75 values in males living in Sari (4.46±1.00) (12) and Kurdistan (4.45±1.23) (13) were higher than FEF25-75 value in Hamedani residents (4.19±1.05). A further point was that our finding was rather similar to the FEF25-75 value reported by ERS, nevertheless larger than one declared in ITS, Morris, and Knudson standards.

Moreover, our study evaluated the lung function volumes for males and females considering their stature, in which we found that height was an important factor in the value of the ventilatory function. In this regard, FVC, FEV1, and FEF25-75 increased in those taller than 170 *cm*. Our finding was, in part, in agreement with the study performed on the people living in Sari (12) and India (17). However, in the current study, FEV1/FVC declined in this group. Furthermore, stature showed a positive association with the parameters, except with FEV1/FVC which had a negative correlation. Conversely, there was no relationship between weight and the spirometric indexes in the present study, which was in contrast with the finding resulting by Khazraee *et al* (18). They studied 50 construction workers and 50 referent workers from the food industry in the southeast of Fars province in Iran and found a significant positive correlation.

As such, age had an inverse correlation with all of the spirometric parameters calculated in our study, as the parameters were reduced with the advancing age. About FEV1/FVC ratio, there was a consensus between our finding and one in the study (18). Also, in the literature (12), age showed the same correlation with FVC, FEV1, and FEF25-75. Age-related change can be justified by physiologic changes, respiratory muscle fatigue, being exposed to smoke, doing the work which causes lung function to severely suffer. Regarding the correlation between age and height with FVC and FEV1,, the study (7) showed the same results as our findings.

Conclusion

Determination of normal values of spirometric indices is a necessity for various societies due to their importance in the diagnosis and treatment of respiratory diseases. Based on the results of studies conducted in different geographical parts of the world, different values of spirometric indices have been reported (19). In addition to the effects of age, sex, height, and weight on the above indicators, environmental factors, geographic factors, and altitude are also effective (20). In the present study, the normal values of these indicators were obtained separately for men and women from three different age groups.

The values obtained in the present study for the FVC, FEV1, and FEF25-75 parameters were higher, and the FEV1/FVC value was lower than those reported in domestic and foreign studies. On the other hand, age and height variables were able to significantly predict spirometric parameters, moreover, spirometric parameters decreased with age and increased with height. It is recommended to extract normal spirometric parameters in each region and to consider the normal values of each region concerning age, sex, and height when interpreting the spirometric indices of individuals.

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Consent statement

Written informed consent was obtained from the patients for publication of this case report and accompanying images. This accreditation is valid within the framework of the accepted national and international ethical norms and principles for biomedical research as well as the guidelines and protocols of the Islamic Republic of Iran, Ministry of Health, and Medical Education. Specific Code: IR.UMSHA.REC (Issue Date: 2018-03-05).

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Conflict of Interest

This manuscript is original work and has not been submitted or is not under consideration for publication elsewhere. All the authors have reviewed the manuscript and approved it before submission. None of the authors have any conflict of interest from publishing this work.

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