Prediction Equation for Spirometric Parameters in Cairo Governorate Adult Population

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Received July 16, 2021, accepted August 16, 2021
doi: 10.47104/ebnrojs3.v3i3.212

ABSTRACT

Context: Spirometry is the most common one used in assessing, diagnosing, and managing patients with different lung diseases. Prediction equations developed in one set of the population may not apply to a different set of populations.
Aim: This work aimed to develop prediction equations for spirometry pulmonary function parameters in a sample of the adult Egyptian population in the Cairo governorate. The secondary aim was to compare our derived equations of pulmonary function with international reference figures used in our spirometric lab facilities.
***Methods*:** This observational cross-sectional population-based study was carried out at Embaba Chest Hospital upon 610 normal healthy subjects, aged between 20 - 45 years old. All subjects were subjected to history, clinical examination, and pulmonary function tests. These subjects were randomly selected in a cluster from registration records in different official health care facilities or community health centers. Subjects from records were invited by calling through land phone, cell phone, or e-mails. This study compared the international reference figures of mean predicted spirometry values with our derived predicted values of lung function parameters.
Results: The predicted equations for FEV1 were [(3.429+(-0.028*Age)+(-0.017*weight)+(0.018*height)], and [1.238+(-0.005*Age)+(-0.006*weight)+(0.014*height)] for males and females respectively. The predicted equations for FVC were [4.556+(-0.016*Age)+(-0.012*weight)+(0.01*height)], and [2.494+(-0.009*Age)+(-0.005*weight)+(0.0100*height)] for males and females respectively. It was found that the Egyptian predicted mean values were within the lower limit of normal LLN and upper limit normal ULN when each of these prediction equations was used. These results were higher than US population with regards to FEV1 4.089(0.498) Vs 3.88(0.04) [p<0.001] in males, but non-significant in females 2.865 (0.171) Vs2.85 (0.33) [p0.449]. FVC was found statistically higher in Egyptian population in female gender 3.513(0.164) Vs 3.36(0.33) [p<0.001] and non-significant difference in males 4.743(0.31) Vs 4.74(0.36) [p0.932] compared to US population. Besides, there were considerable differences between Omani and Jordanian populations and Egyptian populations, on the other hand regarding FEV1 and FEF $_{25-75\%}$ in the male gender.
Conclusion: The Linear regression equations had a direct linear correlation with height and inverse linear correlation with age. The implemented reference values utilized in our lab's facilities are particularly suited with the present study's derived predicted lung function equation. In addition, equations had diverse determination coefficients from those reported by authors in adult Omani and Jordanian populations.

Keywords: Prediction equations, spirometry parameters, adult population

1. Introduction

Spirometry is a vital investigation carried out by pulmonologists and experienced nurses. Interpretation of these spirometry data helps diagnose, detect, and classify the severity of the underlying obstructive or restrictive abnormality. However, the interpretation of normal and diseased ones depends on the predicted values, which depend mainly on anthropometry parameters, gender, and ethnicity, though environmental, genetic, socioeconomic, and technical factors also contribute *(Chhabra 2009).*

Wide variations have been observed in diverse ethnic groups. Reference formulas are used to determine normal ranges of spirometry results. Reference plays an important role in establishing the volumes measured in an individual fall within a range expected in a healthy person of the same gender, height, age, and geographic location *(Ostrowski et al., 2005).* Proposing updated regression equations for spirometry variables in the adult population is useful in managing patients with respiratory diseases.

2. Significance of the study

Because of the scarcity of prediction equations for spirometric variables in Egypt, only one study was conducted in the middle Egypt population by *Abdelazaher (2010)*. The current observational cross-sectional population-based study was carried out in lower Egypt, Cairo Governorate, to fill somewhat the present gap.

3. Aim of the study

This work aimed to develop prediction equations for spirometric pulmonary function parameters in a sample of the adult Egyptian population in the Cairo governorate. The secondary aim was to compare our derived equations of pulmonary function testing with international reference figures used in our hospital spirometric lab facilities.

4. Subjects & Methods

4.1. Research design

An observational, randomized cross-sectional population-based study.

4.2. Study setting

The study was conducted at Embaba Chest Hospital between January 2020 to December 2020.

4.3. Subjects

The study recruited 610 persons randomly selected in clusters from different geographical areas in Cairo (west, east, middle, south, and north areas). They were collected from registration records in different official health care facilities or community centers. Subjects from records were invited by calling through landline, cell phone calls, or e-mails.

Inclusion criteria

- Healthy males or females' subjects of Egyptian nationality from Cairo governorate.
- Subjects aged from 20 to 45 years old.

Exclusion criteria

- Smokers for the past five years.
- Subjects with a history of chronic respiratory illness such as COPD, tuberculosis, or bronchial asthma, or a history of respiratory conditions that could result in dysfunction due to, e.g., abnormalities in vertebral column or thoracic cage.
- A subject having pulmonary or upper respiratory tract infections in the past seven days and had presented with respiratory symptoms.
- Subjects have any cardiac abnormality or presenting with physician-diagnosed heart diseases that may affect lung function before the date of recruitment.
- Subject working or is habitant at the polluted environment.
- According to the standard American Thoracic Society, subjects notably perform the pulmonary function tests imprecisely *(Graham et al., 2019).*

4.4. Tools of data collection

4.4.1. Patient Assessment Record

The researchers developed it to record the patients' medical examination findings such as vital signs, age and sex percentile, anthropometric measures including weight in kilograms and height in centimeters plotted against standard deviation curves for age and sex. besides, body mass index, local chest examination, and pulmonary function test.

4.4.1. Pulmonary Function Test Spirometry

It was used to assess the pulmonary function tests using spirometry, type Body box spirometry, ZAN/230.

4.5. Procedures

Following the approval of the Scientific Research and Ethical Committee of the Faculty of Medicine, Ain Shams University, informed consent was taken from each participating subject. All participants were subjected to the following investigations:

- Medical history includes age, sex, occupation, residence, smoking history, and any chronic or acute health abnormalities.
- General examination: Vital signs, anthropometric measures including height and weight.
- Local chest examination: including inspection, palpation, percussion, and auscultation.
- Pulmonary function tests using spirometry (Body box spirometry, ZAN/230). The subject wore light clothing and was barefoot. After explaining the test procedure, the subject was asked to wear a nose clip and was encouraged to produce the greatest expiratory flow in as long as he/she could perform. All individuals underwent the spirometry tests in the sitting position between 8 am - 11 am, and the maneuvers were repeated at least three times to meet the highest value according to the standards of American Thoracic Society tests performance. The largest values from acceptable tests were reported for each parameter.

Measurements included FEV1, FVC, and FEF 25-75. Normal values of spirometric parameters are

- Forced expiratory volume in the first second (FEV1) (>80% predicted).
- Forced vital capacity (FVC) (>80% predicted).
- FEV1/FVC ratio (>80% predicted).
- FEF_{25-75}(>70% predicted) *(Pierce & Johns, 2004).*

5.6. Data analysis

Data analysis was performed using the software SPSS (Statistical Package for the Social Sciences) version 20. Quantitative variables were described using mean and standard deviation, and categorical variables were described using their absolute frequencies.

An independent sample t-test was used to compare means between two groups when data were normally distributed. Pearson (for normally distributed data) and the correlation coefficient were used to assess correlations between two continuous variables.

Linear stepwise regression analysis created an equation for lung function prediction using significant factors resulting from the correlation process. Paired sample t-test was used to measure agreement between actual and predicted lung functions.

The level of statistical significance was set at 5% ($p \leq 0.05$). A highly significant difference was present if $p \leq 0.001$.

5. Results

Table 1 reveals the characteristics of enrolled subjects where 50.5% of the studied population were males, weight and height were significantly higher among males than females, and there was no significant difference between genders regarding age.

Table 2 shows that mean pulmonary function tests FEV1, FVC, FEV1/FVC, and FEF_{25-75} measurements were significantly higher among males than females.

Table 3 reveals a highly statistically significant negative correlation between age and weight with the spirometric measurements and a highly statistically significant positive correlation between height and all measured spirometric functions in both males and females. FEV1/FVC showed no significant correlation with age in the studied female group compared to the male group.

Table 4 age (unstandardized β=-0.012, p<0.05), weight (unstandardized β=-0.006, p<0.05) and height (unstandardized β=0.011, p<0.05) were independently significantly correlated to FEF_{25-75} among the studied females. Age (unstandardized β=-0.043, p<0.05), weight (unstandardized β=-0.021, p<0.05) and height (unstandardized β=0.032, p<0.05) were independently significantly correlated to FEF_{25-75} among the studied males.

Table 5 demonstrates the prediction equation for measuring FEF_{25-75} in females as: 1.702+(-0.12*Age)+(-0.006*weight)+(0.011*height). FEF 25-75 ranged from 2.2619 to 3.1209 with a mean of 2.712±0.19773 among the studied females. The prediction equation for measuring FEF_{25-75} in males was: 1.66+(-0.043*Age)+(-0.021*weight)+(0.032*height). FEF_{25-75} ranged from 2.269 to 5.127, with a mean of 3.7591±0.74313 among the studied males.

Table 6 revealed that age (unstandardized β=-0.005, p<0.05), weight (unstandardized β=-0.006, p<0.05), and height (unstandardized β=0.014, p<0.05) were independently significantly correlated to FEV1 among the studied females. Age (unstandardized β=-0.028, p<0.05), weight (unstandardized β=-0.017, p<0.05) and height (unstandardized β=0.018, p<0.05) were independently significantly correlated to FEV1 among the studied males.

Table 7 shows that the prediction equation for measuring FEV1 in females was: 1.238+(-0.005*Age)+(-0.006*weight)+(0.014*height). FEV1 ranged from 2.4355 to 3.2437, with a mean of 2.8648±0.17228 among the studied females. The prediction equation for measuring FEV1 in males was: 3.429+(-0.028*Age)+(-0.017*weight)+(0.018*height). FEV1 ranged from 3.1020 to 5.0192 with a mean of 4.0894±0.49791 among the studied males.

Table 8 shows that age (unstandardized β=-0.009, p<0.05), weight (unstandardized β=-0.005, p<0.05), and height (unstandardized β=0.010, p<0.05) were independently significantly correlated to FVC among the studied females. Age (unstandardized β=-0.016, p<0.05), weight (unstandardized β=-0.012, p<0.05) and height (unstandardized β=0.01, p<0.05) were independently significantly correlated to FVC among the studied males

Table 9 demonstrates the prediction equation for measuring FVC in females was: 2.494+(-0.009*Age)+(-0.005*weight)+(0.0100 *height). FVC ranged from 3.135 to 3.8561, with a mean of 3.5131±0.16387 among the studied females. The prediction equation for measuring FVC in males was: 4.556+(-0.016*Age)+(-0.012*weight)+(0.01*height). FVC ranged from 4.1262 to 5.3585, with a mean of 4.7432±0.30956 among the studied males.

Table 10 reveals the stepwise regression analysis of factors significantly correlated to FEV1/FVC. Weight (unstandardized β=-0.001, p<0.05) and height (unstandardized β=0.001, p<0.05) were independently significantly correlated to FEV1/FVC among the studied females. Age (unstandardized β=0.002, p<0.05), Weight (unstandardized β=-0.001, p<0.05), and height (unstandardized β=0.001, p<0.05) were independently significantly correlated to FEV1/FVC among the studied males.

Table 11 reveals the prediction equation for measuring FEV1/FVC in females was: 0.64+(-0.001*weight)+(0.00*height). FEV1/FVC ranged from 0.7788 to 0.8495, with a mean of 0.8169±0.01473 among the studied females. The prediction equation for measuring FEV1/FVC in males was: 0.839+(-0.002*Age)+(-0.001*weight)+(0.001*height). FEV1/FVC ranged from 0.8109 to 0.984, with a mean of 0.872±0.03277 among the studied males.

Table 12 shows the predicted FEV1 is significantly lower than Jordanian and higher than Omani populations, respectively, but there were non-significant statistical differences compared to the US population.

Table (1): Comparison between gender of patients regarding age, weight, and height measurements.

Parameter	Gender		t-test*	p
	Male(n=308) 50.5%	Female (n=302) 49.5%		
	Mean ± SD	Mean ± SD		
Age (year)	32.12±8.9	33.31±0.49	-1.681	0.093
Weight (kg)	89.42±11.397	81.133±13.915	8.041	<0.001
Height (cm)	170.52±7.0771	166.72±6.426	6.959	<0.001

**Independent sample t-test*

Table (2): Comparison between gender of patients regarding spirometric measurements.

Parameter (liter)	Gender		t-test*	p
	Male (n=308)	Female (n=302)		
	Mean ± SD	Mean ± SD		
FEV1	4.089±0.632	2.865±0.262	31.141	<0.001
FVC	4.743±0.526	3.513±0.318	35.033	<0.001
FEV1/FVC	0.872±0.048	0.817±0.055	13.065	<0.001
FEF25 – 75	3.759±0.907	2.713±0.405	18.47	<0.001

**Independent sample t-test*

Table (3) Correlation between spirometric measurements and anthropometric characteristics in males and females.

Parameter	Age (year)		Weight (kg)		Height (cm)	
In males						
	R*	p	r	p	r	P
FEV_1	-0.736	<0.001	-0.699	<0.001	0.58	<0.001
FVC	-0.544	<0.001	-0.534	<0.001	0.426	<0.001
FEV_1/FVC	-0.654	<0.001	-0.568	<0.001	0.485	<0.001
FEF_{25-75}	-0.766	<0.001	-0.71	<0.001	0.625	<0.001
In females						
Parameter	Age (year)		Weight (kg)		Height (cm)	
	r	p	r	p	r	p
FEV_1	-0.467	<0.001	-0.534	<0.001	0.546	<0.001
FVC	-0.427	<0.001	-0.397	<0.001	0.399	<0.001
FEV_1/FVC	-0.09	0.117	-0.222	<0.001	0.224	<0.001
FEF_{25-75}	-0.41	<0.001	-0.38	<0.001	0.368	<0.001

**r Pearson correlation coefficient*

Table (4): Linear stepwise regression analysis of factors significantly correlated to FEF_{25-75} among the studied females and males.

Variables	Unstandardized Coefficients		Standardized Coefficients	t	p	95.0% Confidence Interval	
	β	Std. Error	β			Lower	Upper
In females							
(Constant)	1.702	0.698		2.439	0.015	0.328	3.075
Age (year)	-0.012	0.003	-0.243	-4.064	<0.001	-0.017	-0.006
Weight (kg)	-0.006	0.002	-0.195	-3.295	<0.001	-0.009	-0.002
Height (cm)	0.011	0.004	0.176	2.999	0.003	0.004	0.018
In males							
(Constant)	1.660	1.026		1.619	0.107	-0.358	3.678
Age (year)	-0.043	0.005	-0.425	-8.114	<0.001	-0.054	-0.033
Weight (kg)	-0.021	0.004	-0.269	-5.403	<0.001	-0.029	-0.014
Height (cm)	0.032	0.005	0.247	6.111	<0.001	0.021	0.042

Table (5): Prediction equation of FEF_{25-75} among the studied females and males.

Parameter	Equation	R	R^2	SEE	1.64* residual SD	Mean ±SD	Lower limit	Upper limit
FEF_{25-75} in females	1.702+(-0.12*Age)+ (-0.006*weight)+(0.011 *height)	0.488	0.238	0.35515	0.5795268	2.712±0.19773	2.2619	3.1209
FEF_{25-75} in males	1.66+(-0.043*Age)+(-0.021*weight) +(0.032 *height)	0.819	0.671	0.52255	0.8527836	3.7591±0.74313	2.269	5.127

Table (6): Linear stepwise regression analysis of factors significantly correlated to FEV1 among the studied females and males.

Variables	Unstandardized Coefficients		Standardized Coefficients	t	p	95.0% Confidence Interval for B	
	β	Std. Error	β			Lower	Upper
In females							
(Constant)	1.238	0.392		3.160	0.002	0.467	2.009
Age (year)	-0.005	0.002	-0.175	-3.388	0.001	-0.009	-0.002
Weight (kg)	-0.006	0.001	-0.313	-6.124	<0.001	-0.008	-0.004
Height (cm)	0.014	0.002	0.335	6.590	<0.001	0.010	0.018
In males							
(Constant)	3.429	0.769		4.461	<0.01	1.917	4.942
Age	-0.028	0.004	-0.395	-7.021	<0.001	-0.036	-0.020
Weight	-0.017	0.003	-0.303	-5.670	<0.001	-0.023	-0.011
Height	0.018	0.004	0.201	4.629	<0.001	0.010	0.026

Table (7): Prediction equation of FEV1among the studied females and males.

Parameter	Equation	R	R^2	SEE	1.64*residual SD	Mean±SD	Lower limit	Upper limit
FEV1 in females	1.238 + (-0.005*Age) + (-0.006*weight) + (0.014 *height)	0.658	0.433	1.9814	0.325343	2.8648±0.17228	2.4355	3.2437
FEV1 in males	3.429 + (-0.028*Age) + (-0.017*weight) + (0.018 *height)	0.787	0.62	1.9814	0.6392064	4.0894±0.49791	3.1020	5.0192

Table (8): Linear stepwise regression analysis of factors significantly correlated to FVC among the studied females and males.

Variables	Unstandardized Coefficients		Standardized Coefficients	t	p	95.0% Confidence Interval	
	β	Std. Error	β			Lower	Upper
			In females				
(Constant)	2.494	0.538		4.632	<0.001	1.435	3.554
Age (year)	-0.009	0.002	-0.245	-4.180	<0.001	-0.013	-0.005
Weight (kg)	-0.005	0.001	-0.198	-3.420	0.001	-0.007	-0.002
Height (cm)	0.010	0.003	0.205	3.546	<0.001	0.005	0.016
			In males				
(Constant)	4.556	0.838		5.434	<0.001	2.906	6.206
Age	-0.016	0.004	-0.266	-3.596	<0.001	-0.024	-0.007
Weight	-0.012	0.003	-0.266	-3.785	<0.001	-0.019	-0.006
Height	0.010	0.004	0.141	2.473	0.014	0.002	0.019

Table (9): Prediction equation of FVC among the studied females and males.

Parameter	Equation	R	R^2	SEE	1.64*residual SD	Mean ±SD	Lower limit	Upper limit
FVC in females	2.494+(-0.009*Age)+(-0.005*weight) +(0.010*height)	0.515	0.265	0.27419	0.4472116	3.5131±0.16387	3.135	3.8561
FVC in males	4.556+(-0.016*Age)+(-0.012*weight) +(0.010*height)	0.589	0.347	0.42719	0.6971476	4.7432±0.30956	4.1262	5.3585

Table (10): Linear stepwise regression analysis of factors significantly correlated to FEV1/FVC among the studied females and males.

Variables	Unstandardized Coefficients		Standardized Coefficients	t	p	95.0% Confidence Interval	
	β	Std. Error	β			Lower	Upper
			In females				
(Constant)	0.640	0.099		6.489	<0.001	0.446	0.834
Weight (kg)	-0.001	0.000	-0.157	-2.547	0.011	-0.001	0.000
Height (cm)	0.001	0.001	0.158	2.569	0.011	0.000	0.002
			In males				
(Constant)	0.839	0.070		11.915	<0.001	0.701	0.978
Age	-0.002	<0.001	-0.455	-6.753	<0.001	-0.003	-0.002
Weight	-0.001	<0.001	-0.156	-2.433	0.016	-0.001	0.000
Height	0.001	<0.001	0.147	2.822	0.005	0.000	0.002

Table (11): Prediction equations of FEV1/FVC among the studied females and males.

Parameter	Equation	R	R^2	SEE	1.64*residual SD	Mean ±SD	Lower limit	Upper limit
FEV1/FVC in females	0.64+(0.001*weight)+(0.001*height)	0.266	0.071	0.05358	0.0875924	0.8169±0.01473	0.7788	0.8495
FEV1/FVC in males	0.839+(0.002*Age)+(0.001*weight)+(0.001*height)	0.676	0.457	0.03589	0.0585808	0.872±0.03277	0.8109	0.984

Table (12): Comparison between predicted values obtained by prediction equations in the present study and the selected equations from literature.

	Predicted values			
	Current study	**Omani**	**Jordanian**	**US population**
	Mean±SD	**Mean±SD**	**Mean±SD**	**Mean±SD**
Males				
No. of subject	308	256	144	476
Age range	20-45	18-65	20-60	21-80
FEV_1	4.089±0.498	3.3 ±0.33 [p <0.001]*	4.12±0.45 [p 0.457]	3.88±0.04 [p <0.001]
FVC (L)	4.743±0.31	3.95±0.4 [p <0.001]	4.92±0.46 [p <0.001]	4.74±0.36 [p 0.932]
$FEF_{25-75\%}$	3.759±0.743	4.09±0.37 [p <0.001]	3.84±0.48 [p 0.249]	3.87±0.58 [p <0.05]
Females				
No. of subjects	302	163	117	927
Age range	20-45	18-65	20 – 60	21 – 80
FEV_1	2.865±0.171	2.49±0.31 [p <0.001]	2.93±0.35 [p 0.01]	2.85±0.33 [p 0.449]
FVC (L)	3.513 ±0.164	2.91±0.34 [p <0.001]	3.510±0.36 [p0.003]	3.36±0.33 [p <0.001]
$FEF_{25-75\%}$	2.712±0.198	3.43±0.33 [p <0.001]	3.13±0.47 [p<0.001]	3.17 ±0.45 [p <0.001]

**Independent sample t test.*

6. Discussion

Until recently, the reference equations available for pulmonary function tests (PFTs) have had several weaknesses: They have often been based on relatively weak samples of normal subjects; they used mathematical models that are not very efficient in describing the evolution of PFTs over age; there were different equations for children/adolescents and adults; the expression of the results solely as a percentage of the predicted value did not provide a good indication of the statistical significance of any difference that may exist between a measured value and its reference value *(Guillien et al., 2018).*

When comparing actual to predicted values, the use of Standardized Residuals Deviation, RSD, is recommended, calculated as Standardized residual = observed - predicted / RSD *(Kenton & Khartit, 2020).*

The researcher can obtain a dimensionless index which indicates how far the observed value is removed from the predicted one, and therefore how likely it is that the observed value occurs in reference population; For example, a standardized residual of 0 indicates that the observed value is equal to the reference value (hence is at the 50th percentile). Indeed, even within a particular subgroup of participants, there are likely to be large amounts of genetic and socioeconomic heterogeneity and differences in environmental exposures *(Graham, 2019; Via, 2011; Moreno-Estrada, 2014).*

The prediction equation in the current study for each lung function value can be estimated using the following equation:

Predicted lung function= (height x coefficient)– (age x coefficient)– (weight x coefficient) ± constant.

If we repeatedly obtained values from a similar normal population, nighty nine percent of which fall within (-1.64 to +1.64). If there is no concern of higher values being abnormal, the 5% error on the lower tail of the curve and the (-1.64) can be defined as lower limit normal (LLN) of the mean value. The advantage of using a Z score instead of the percentage predicted in recognizing LLN and ULN (upper limit normal) is that it can be applied to the whole population *(Haynes et al., 2020).*

In normal spirometry, FVC, FEV_1, and FEV_1 -to-FVC ratio measurements are above the lower limit of normal. The lower limit of normal is defined as the result of the mean predicted value (based on the patient's sex, age, and height) minus 1.64 times the standard error of the estimate from the population study on which the reference equation is based. The ATS has recommended using lower limits of normal instead of the 80% of predicted for setting the threshold that defines abnormal test results. *McCarthy & Dweik (2020).*

In the present study, the necessity of deriving predicted equations and the implemented international mean values with standard deviation before our estimates would not introduce ambiguity in identifying the weighted independent and dependent variables involved in their derivation. Our present study showed that weight and height were significantly higher among males than females, but there was no significant relationship between gender and age of the whole study's participants.

Therefore, we targeted primarily to derive prediction equations for the Egyptian population considering RSD and secondary to test the accuracy of these predicted equations compared to standardized reference values available in our lab's facilities.

Our study found that the Egyptian predicted mean values were above the LLN when these prediction equations were used. The implicit of this statement is that the implemented reference values utilized in our lab's facilities are particularly suited when referred to local ethnicity.

Abdel Hafez et al. (2010) measured some pulmonary function parameters in healthy adult subjects in middle Egypt, Assiut governorate, where seven hundred and sixty subjects, including 405 males and 355 females, were enrolled. Our results agreed with those of *Abdel Hafez et al. (2010).* who stated that age and weight were negatively correlated, and height was positively correlated with the spirometric values.

These results agreed with *Sutherland et al. (2008),* whose study was done on healthy subjects of 20-50 years of age (52 males and 55 females) and highlighted the effect of adiposity on lung function. Most of that study's participants were European. Similarly, *Desai et al. (2016),* in their study, developed prediction equations for spirometry parameters for the western Indian population in 310 subjects, 185(59.7%) males and 125(40.3%) females. They suggested a significant correlation of the weight parameter with FVC, FEV1, and PEFR.

In the current study, the ratio FEV1/FVC was not statistically significantly correlated with age, but weight and height were independently significantly correlated among our studied subjects (Table10). Abdel Hafez et al. (2010) demonstrated that in FEV1/FVC measurements, the percent of subjects below LLN was 66.31 percent predicted. Given these findings, underestimating FEV1/FVC in their interpretation and thus potential lung function impairments could exist. Given the higher prevalence of asthma and chronic obstructive pulmonary disease in these populations, the ratio of FEV1/FVC anticipated changed, and therefore, the need for accurate reference equations is especially acute. *Graham, et al. (2019); Via et al. (2011); Moreno-Estrada et al. (2014).*

Our study compared the derived predicted values for Egyptian lung function parameters with those from publications of lung function in Omani, Jordanian and united states populations, *Al-Rawas (2009); Sliman et al., (1981), Hankinson, et al. (1999).* Review of literature*, our study* showed statistically significant differences compared to Omani and Jordanian populations except for FEV1 measurements in males. Our results agreed with *Pellegrino et al. (2005),* who stated the ethnic variation in lung function is well documented, where FVC and FEV1 in Caucasians were consistently larger than other ethnic groups, including Asians, Africans, American blacks, and Hispanics.

However, our study's most salient significant result is that spirometric values in our area, similar to *Abdel Hafez et al.(2010)*, that FEV1 was higher than the US population (p<0.001), and comparatively non-significant results for FVC in males. On the contrary, FEV1 in female genders, in contrast to FVC, had no significant difference compared to the US population. This finding disagreed with Abdel Hafez et al., who stated that FEV1 and FVC were statistically significantly different from the US population. To capitulate, the female gender in the present study does not conform to the previous study done by *Abdel Hafez et al.*

Additionally, there was no significant difference between predicted FEV1 in the current study and those recruited from the Jordanian population, while the predicted FEV1 among males in the current study was significantly higher than the Omani male genders populations (p<0.001). There was no significant difference between predicted FEF_{25-75} in the current study and the one recruited from the Jordanian population in males, whereas the predicted FEF_{25-75} in the current study was significantly lower than the Omani populations in both males and females' genders population (p<0.001).

There were significant differences between predicted FVC in the current study and those recruited from the Jordanian population with lower results in our mean values. In contrast, the predicted FVC in the Omani population was relatively less than our results from the statistical point of view.

However, the predicted FEV1 in the current study was significantly higher than the Omani and US studies among male participants, whereas FVC predicted equations showed a significant statistical difference between our study and Omani and US in females' populations.

There was no significant difference between predicted FEF_{25-75} in the current study and the one recruited from the Jordanian and US populations in males, whereas the predicted FEF_{25-75} in the current study was significantly lower than the Omani populations in males (p<0.001). In females, $FEF_{25-75\%}$ was statistically significantly lower than Jordanian, Omani, and US populations.

Abdel Hafez et al. (2010) showed that in females, the predicted values, except for FVC, were significantly (P < 0.001) lower than these of the Omani population. This finding disagrees with our results where all variables, except $FEF_{25-75\%}$, were higher in the Egyptian population than the Omani population in both genders. The hypothesis of the impact of the high prevalence of sickle cell anemias in gulf areas may support our results.

However, the difference between our results and that of *Abdel Hafez et al. (2010)* could be referred, as well, to the percentage numbers of female genders recruited in their sample. This finding is faithful as prediction equations in the female Egyptian population, including weight and height, are less than males in the present study. The increased body fat percentage in females than males in the Egyptian population may be the main cause that decreases respiratory function in females. Additionally, in *Abdel Hafez et al. (2010)* study, the weight in females was stated less than males, in contrast, to the present study.

A shortcoming of the present study was the pandemic crisis of Covid19 that limits the number of participants included. However, all precautions had been taken to fulfill inclusion and exclusion criteria, and all equipment was cautiously and repeated sterilized before processing was starting.

7. Conclusion

The implemented reference values utilized in our lab's facilities are particularly suited with the predicted lung function equation derived in the present study and match the standard of care for the adult Egyptian healthy population. Our results showed that mean values of some pulmonary functions are close to Jordanian rather than Oman population for the female population but closely related to FEV1 in USA male dominance.

8. Recommendations

The need for global and national reference predicted equations are especially needed in future research.

9. References

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