Lung function reference values in Iranian adolescents

N. Ahmadial,[1] S. Khamnei,[1] M. Abedinzadeh,[1] H. Najafi[1] and M. Mohammadi[1]

القِيَم المرجعية لوظائف الرئة لدى المراهقين في إيران

ناصر أحمدي أصل، سعيد خامنة، محمود عابدين زاده، هوشنك نجفي، مسلم محمدي

الخلاصة: تتَّسم المعلومات المتعلقة بالقِيَم المرجعية لحجم الرئة لدى الإيرانيين بأنها غير كافية. وقد أُجريت هذه الدراسة على متثابتات وظائف الرئة في 302 من الطلاب الإيرانيين غير المدخنين (152 من الذكور، و150 من الإناث). وبيَّنت الدراسة أن قياسات وظائف الرئة تترابط ترابُطاً قوياً مع الطول لا مع منسب كتلة الجسم. ولوحظت فروق يُعْتَدُّ بها إحصائياً بين بعض المتثابتات التي تم قياسها وبين القِيَم المرجعية التي حدَّدتها جمعية أمراض الصدر الأمريكية للقوقازيين (P>0.05). ولوحظ أيضاً ارتفاع السعة الوظيفية المتبقية (أعلى بنسبة 110٪) وانخفاض سعة الشهيق (أقل بنسبة 86٪) بين الذكور، مقارنةً مع القِيَم المرجعية.

ABSTRACT There is insufficient information about reference values for pulmonary volumes for Iranian populations. A study of lung function parameters was made on 302 non-smoking healthy Iranian students (152 male and 150 female). Lung function measures correlated strongly with height but not with body mass index. There were significant differences between some of the measured parameters and American Thoracic Society reference values for Caucasians ($P < 0.05$). Of note is the high functional residual capacity (110% higher) and low inspirational capacity (86% lower) in males compared with the reference values.

Valeurs de référence pour la fonction pulmonaire chez des adolescents iraniens

RÉSUMÉ Il n'y a pas suffisamment d'informations sur les valeurs de référence pour les volumes pulmonaires dans la population iranienne. Une étude des paramètres de la fonction pulmonaire a été réalisée sur 302 étudiants iraniens non fumeurs en bonne santé (152 sujets de sexe masculin et 150 de sexe féminin). Les mesures de la fonction pulmonaire étaient fortement corrélées avec la taille mais pas avec l'indice de masse corporelle. Il y avait des différences significatives entre certains des paramètres mesurés et les valeurs de référence de l'American Thoracic Society pour les Caucasiens ($p < 0,05$). Différences notables : la forte capacité résiduelle fonctionnelle (110 % supérieure) et la faible capacité inspiratoire (86 % inférieure) chez les sujets de sexe masculin par rapport aux valeurs de référence.

[1]Tuberculosis and Lung Research Centre, Tabriz University of Medical Sciences, Tabriz, Islamic Republic of Iran (Correspondence to N. Ahmadial: ahmadyn@tbzmed.ac.ir).
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Introduction

Pulmonary function testing is a routine procedure for the assessment and monitoring of respiratory diseases. Normal spirometric values are valuable reference tools for this purpose. These indices have been shown to vary according to age, height, sex, and body size [*1,2*]. An influence of race or ethnicity on lung volumes has also been shown. For example, normal lung volumes for a given age, height and sex are lower for African Americans compared with those for white Americans [*3*]. Lower socioeconomic status is also associated with lower pulmonary function in both children and adults [*4*]. Using reference equations for predicting normal values appropriate for a particular racial or ethnic group is an integral part of assessing lung function. There is little data available from pulmonary function tests in the Islamic Republic of Iran. The currently used reference values are those for Caucasians proposed by the American Thoracic Society and the European Respiratory Society [*5,6*]. In this context, Iranians are classified as Indo-Europeans, but the Islamic Republic of Iran has experienced considerable migration and intermixing of many races and ethnic groups throughout the centuries, including Turks and Arabs. Therefore it could be expected that the genetic background as well as the physical properties of the population have changed.

Three Iranian studies of respiratory function are available, one from the northeast city of Meshed [*7*] and others from the central cities of Tehran [*8*] and Isfahan [*9*]. These studies lack data on residual volume (RV) and therefore functional residual capacity (FRC), which are essential parameters for assessing obstructive and restrictive respiratory diseases. Moreover, the fact that the studies were carried out with a limited number of subjects may be problematic for generalization of the relevant data to the whole population. Therefore we planned a more complete series of studies of respiratory function on different age ranges in the Islamic Republic of Iran that would include RV and FRC assessment in the study protocol. The present study reports the data for respiratory parameters in young adults in Tabriz city.

Methods

The study was carried out from February 2004 to May 2005. A total of 349 nonsmoking students were invited for interview. The students were all medics and paramedics taking part in physiology practical classes within the above time interval. All were symptomatically healthy and had no record of cardiopulmonary disease. Lung function measurements were performed between 08:00 and 16:00 hours. Standing height and body weight were measured in all subjects without wearing shoes by a calibrated weighting scale and stadiometer, and body mass index (BMI) was calculated for each subject. Thorax circumflex was measured at subaxillary level in each subject.

For respiratory measurements the Zan plethysmograph was used (Zan 500 Meßgerate GmbH, Germany) and all tests were performed according to the American Thoracic Society criteria to ensure quality [*10*]. Two trained and certified technicians made all measurements. Each student performed at least 3 sets of trials. Lung function results were reported under body temperature and pressure saturated (BTPS) conditions. Each subject, wearing a nose-clip, was seated in the box and a demonstration trial of the shutter mechanism and proper breathing technique was carried out. The actual measurements were performed after relative thermal equilibrium had been achieved a

few minutes following closure of the door. Measurement of thoracic gas volume at the level of FRC was conducted when the box pressure was stable, the subject was relaxed and adapted to the mouthpiece, and volume recording showed a regular end expiratory baseline during at least 4 or 5 tidal breaths. Then at the end of expiration the shutter was closed for 2–3 seconds while the subject maintained the breathing pace without occluding the glottis. In addition to FRC, we also measured RV, residual capacity (RC), inspiratory capacity (IC), vital capacity (VC), total lung capacity (TLC), forced expiratory volume in one second (FEV1), forced vital capacity (FVC) and FEV1/FVC ratio.

Analysis

The final test reports were analysed with *SPSS* software, version 10 using multiple linear regression analysis for each of the parameters to predict an equation. The measured parameters of our subjects were compared with the predicted values for Caucasians of the American Thoracic Society [*5*].The equations were considered to be acceptable if *P*-value was less than 0.05. Independent samples *t*-test was used for comparisons between male and female groups, and paired *t*-test for comparison of the data obtained from the present study with that of other studies.

Results

From among the 349 subjects invited for interview, a total of 34 were excluded from the study (6 for physical disability that prevented their performing the tests, 13 for mild cardiopulmonary problems, 5 for having BMI $\geq$ 30 kg/m^2). Also 13 subjects did not attend the tests. Results for the remaining 302 subjects (152 males and 150 females) are reported.

The anthropometric values determined for both sexes and their statistical comparisons are shown in Table 1. Mean (standard deviation) age for males was 20.4 (1.3) years and for females was 20.5 (1.2) years. Height and weight were significantly different between the 2 groups ($P < 0.001$).

The results of the pulmonary tests are given in Table 2. Males and females were significantly different in all the parameters studied ($P < 0.001$). Comparing the measured parameters of our subjects with the predicted values for Caucasians of the American Thoracic Society, we found significant differences between all parameters except for TLC in females ($P < 0.05$). These values were located within 86%–110% of those derived from prediction equations values for Caucasians for our male subjects (Table 2). The largest variations were for FRC which was significantly higher (110%) and IC which was significantly lower (86%) in males compared with the reference values.

The multiple regression analysis of anthropometric and spirometric parameters are shown in Table 3. In both sexes all the measured parameters except FEV1/FVC had

Table 1 Anthropometric characteristics of the participants

Parameter	Males (n = 152)		Females (n = 150)	
	Mean	SD	Mean	SD
Age (years)	20.4	1.3	20.5	1.2
Height (cm)	172.3	6.5	164.4	8.1***
Weight (kg)	65.3	8.6	60.1	8.8***
BMI (kg/m^2)	21.9	2.7	22.2	2.7
Thorax (cm)	88.8	7.0	79.5	7.1

n = total number of participants.
SD = standard deviation.
***P < 0.001.
BMI = body mass index.

Table 2 Mean lung volumes and capacities in healthy young Iranian males and females and comparison with American Thoracic Society (ATS) reference values for young Caucasians [5]

Parameter	Males (n = 152)					Females (n = 150)				
	Measured values		ATS values		% difference	Measured values		ATS values		% difference
	Mean	SD	Mean	SD		Mean	SD	Mean	SD	
RV(L)	1.69	0.17	1.58	0.08	107*	1.44	0.21	1.37	0.14	105*
IC (L)	3.05	0.31	3.53	0.35	86*	2.20	0.31	2.24	0.34	93*
FRC (L)	3.84	0.22	3.17	0.15	110*	2.86	0.33	2.70	0.17	106*
VC (L)	4.84	0.22	5.16	0.40	94*	3.62	0.40	3.72	0.37	97*
TLC (L)	6.53	0.45	6.70	0.50	97*	5.07	0.57	5.06	0.52	99
FEV1(L)	3.95	0.36	4.20	0.28	94*	3.12	0.44	3.28	0.31	95*
FVC (L)	4.69	0.40	5.04	0.44	93*	3.76	0.42	3.84	0.31	97*
FEV1/FVC (%)	84.4		83.0		101*	87.8		84.0		104

SD = standard deviation; n = total number of participants.
*P < 0.05 (paired t-test).
RV = residual volume; IC = inspiratory capacity; FRC = functional residual capacity; VC = vital capacity; TLC = total lung capacity; FEV1 = forced expiratory volume in 1 s; FVC = forced vital capacity.

a significant correlation with height. TLC had the strongest correlation with height in both sexes. Weight was also significantly correlated with many parameters. BMI had no statistically significant correlation with any of the respiratory parameters in males but it correlated significantly with IRV, IC, ERV and FRC in females. FEV1/FVC had no significant relation either with height or with other anthropometric indices.

Discussion

It is well known that lung function varies between different ethnic groups [*7,11*], and according to factors such as genetic constitution, environmental factors and nutritional status [*4,12,13*]. This study has generated updated pulmonary values for routine tests including RV and FRC for young Iranians. Previous studies in the Islamic Republic of Iran lacked RV and FRC assessments [*7–9*] and this was the reason for carrying out the present investigation.

In agreement with many other studies [*7,12,14*], our lung function measures in young Iranians correlated strongly with height. However, we found no positive correlation between our measurements and BMI. In fact, there was a non-significant negative correlation in this regard. This was probably because we studied volunteers with a normal range of BMI (mean BMI < 30 kg/m^2). Many other researchers have found a negative correlation between BMI and respiratory values [*15–17*]. On the other hand, Harik-Khan et al. found a positive correlation between BMI and respiratory parameters in young individuals which they justified by the effect of muscularity in young populations in contrast to the influence of adiposity in older groups [*4*].

The values of lung function tests for young Iranians were located within 86%–110% of those derived from prediction

Table 3 Multiple regression analysis of spirometric parameters and anthropometric factors in healthy young Iranian males and females

Parameter	Height (cm)		Weight (kg)		BMI (kg/m^2)		Thorax (cm)	
	r	P-value	r	P-value	r	P-value	r	P-value
Males (n = 152)								
TV	0.449	0.000	0.212	0.009	–0.095	0.245	0.305	0.001
IRV	0.547	0.000	0.241	0.003	–0.066	0.423	0.233	0.014
ERV	0.572	0.000	0.294	0.000	–0.048	0.554	0.292	0.002
RV	0.246	0.002	0.004	0.960	–0.105	0.200	–0.103	0.283
IC	0.680	0.000	0.321	0.000	–0.081	0.318	0.327	0.000
FRC	0.645	0.000	0.244	0.002	–0.112	0.169	0.160	0.094
VC	0.753	0.000	0.394	0.000	–0.053	0.517	0.384	0.000
TLC	0.785	0.000	0.315	0.000	–0.138	0.091	0.302	0.001
FEV1	0.426	0.000	0.111	0.173	–0.149	0.067	0.264	0.005
FVC	0.448	0.000	0.176	0.030	–0.129	0.114	0.306	0.001
FEV1/FVC	0.058	0.481	–0.041	0.614	–0.410	0.619	0.006	0.954
Females (n = 150)								
TV	0.341	0.000	0.161	0.050	–0.058	0.484	0.251	0.002
IRV	0.732	0.000	0.607	0.000	0.180	0.028	0.640	0.000
IC	0.726	0.000	0.610	0.000	0.186	0.023	0.637	0.000
ERV	0.515	0.000	0.189	0.020	–0.183	0.025	0.424	0.000
RV	0.782	0.000	0.416	0.000	–0.103	0.209	0.552	0.000
FRC	0.785	0.000	0.366	0.000	–0.175	0.033	0.580	0.000
VC	0.794	0.000	0.567	0.000	0.073	0.372	0.681	0.000
TLC	0.866	0.000	0.564	0.000	0.013	0.876	0.703	0.000
FEV1	0.762	0.000	0.468	0.000	–0.016	0.851	0.639	0.000
FVC	0.586	0.000	0.366	0.000	–0.005	0.916	0.501	0.000
FEV1/FVC	0.057	0.866	0.051	0.537	0.020	0.820	0.084	0.307

r = correlation coefficient; n = total number of participants.
BMI = body mass index.
TV = tidal volume; IRV = inspiratory reserve volume; IC = inspiratory capacity; ERV = expiratory reserve volume; RV = residual volume; FRC = functional residual capacity; VC = vital capacity; TLC = total lung; FEV1 = forced expiratory volume in 1 s; FVC = forced vital capacity.

equations of the American Thoracic Society for Caucasians for our male subjects. Many of the items were similar to predicted reference values; however, particularly notable is the high FRC (110% of reference value) and low IC (86% of reference value) in males compared with the reference values. These can possibly be explained by the impact of ethnicity, nutritional and environmental factors that demand further studies.

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