Evaluation of Lung diffusing capacity for Carbonmonoxide (DLco) in healthy adolescents

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ABSTRACT

In pulmonary function tests (PFT), the selection of prediction equation for lung diffusing capacity for carbonmonoxide (DLco), remains a problem. If a single equation is selected and used by all laboratories, the variation in percent predicted values would be large enough to cause numerous diagnostic errors.

The present study involved 36 healthy adolescents (20 boys and 16 girls aged 13-19 years) with body height (157-170 cm) and body weight (38-63 Kg). Normal values were reported for lung volumes, ventilation and diffusing capacity using spirographic, helium dilution and carbon monoxide single-breath techniques.

Values observed in the present study were comparable to Asians studies but lower than those of Westerns. All pulmonary function parameters were significantly higher in boys, mainly due to larger lung volume, in addition to differences in the level of physical activity and social patterns of life. Regardless to sex, indices of lung volume and diffusion increased with age, body height, and surface area, however, best correlation was observed with body height. Gender specific prediction equations were generated for lung diffusing capacity. Lung diffusion corrected for volume (DLco/VA) seemed independent to sex or body size.

In conclusion, it is not appropriate to rely on prediction equations derived from western populations who had higher levels of normality for DLco. Furthermore, height was the best single predictor for lung diffusion in adolescence age group.

Key words: PFT, DLco, prediction equations, adolescence.

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INTRODUCTION

In the last decade, pulmonary function tests became one of the important clinical tools for the diagnosis and follow up of respiratory diseases in adult as well as in childhood and adolescence age groups.[1]

The development of computerized PFT makes it possible to detect even minor disturbances of pulmonary function. However, PFT has made good contribution in sports medicine, cardiology, surgery and other branches of children and adolescence medicine.

Normal (reference) PFT prediction values for particular age, sex, height and weight groups are necessary for interpreting measured values in order to judge for the presence or absence of respiratory abnormality.

Although PFT in children and adolescents have been studied in different countries,[2, 3, 4, 5] yet similar studies are lacking in Iraq especially by using modern computerized techniques.

This study was undertaken to determine the normal values of lung diffusing capacity for carbon monoxide (DLco) and some of the primary lung volumes and ventilatory parameters in adolescent boys and girls aged 13-19 year.

Generation of gender specific prediction equations for DLco in adolescence age group was another target of the present work.

SUBJECTS & METHODS

The study group consisted of 36 healthy adolescents aged 13-19 years (20 boys and 16 girls). They were students of intermediary and nursing schools (Al-Auruba Nursing School for boys and Baghdad Nursing School for Girls). The studied groups were free from respiratory, cardiac or any acute illness at the time of testing. Smokers were excluded from the study. Study was conducted in the pulmonary function lab. /Baghdad Teaching Hospital / Medical City.

Subject testing was performed between 10 a.m. and 12 p.m. Room temperature varied between 22 to 27 degree centigrade. Spirometry and DLco were performed by a computer based automated system (Master Lab Pro –version 4.3 from JAEGER-Germany). The apparatus consisted of a spirometer, computer and sensors for carbon monoxide and helium. All indices were recorded at ATPS but automatically corrected for (BTPS) except alveolar volume (STPD).

At least three vital capacities were obtained in each subject, and the highest one was taken automatically as the representative vital capacity. FVC, $FEV1_{\%}$, $MMEF_{25\text{-}75\%}$ were measured by flow/volume loops as described by Cogswell *et al.*[3] All calculations were done automatically by computer.

Test procedure was carefully explained and demonstrated for subjects before the test. PFT was performed in a sitting position with nose clips and breathing through a mouthpiece of the spirometer. PFT included:

1. Forced vital capacity (FVC).
2. Percent vital capacity ($FEV_{1\%}$).
3. Maximum midexpiratory flow rate ($MMEF_{25\text{-}75\%}$).
4. Total lung capacity (TLC).
5. Lung diffusing capacity for carbon monoxide (DLco).
6. Volume corrected DLco (DLco/VA).

Dlco was measured by single-breath method DLco-SB (modified Krogh method). Total lung capacity was measured by helium dilution method together with the measurement of DLco-SB since measurement procedure of DLco-SB involves the same spirometry breathing maneuver.[6, 7] Hemoglobin was determined in each subject to exclude anemia.

All data obtained were entered into a personal computer for statistical analysis (SPSS, version 4).

Unpaired student's - t test was used to compare means between sexes. The strength and statistical significance of linear correlation between anthropometrical and lung function parameters were made by Pearson's correlation coefficient (r). Gender specific linear prediction equations were developed by simple regression analysis with the DLco value as dependent variable.

RESULTS

Table (1) shows the mean ±SD values of the physical characteristics of subjects in addition to all tested pulmonary function parameters.

Boys had greater mean height, weight and body surface area than girls ($P<0.01$). Lung volumes (FVC and TLC), ventilatory parameters ($FEV_{1\%}$ and $MMEF_{25\text{-}75\%}$) were significantly higher in boys ($P<0.01$).

The lung diffusing capacity for carbon monoxide (DLco) was significantly higher in boys ($P<0.01$) while no significant difference was noticed between boys and girls in the lung diffusion corrected for volume (DLco/VA).

Table (2) shows the correlation coefficient values (r) for DLco as dependant variable in relation to age, body size parameters (height, weight, BSA), and lung volume (TLC). Regardless to sex, there was a definite increase in DLco with age and body size parameters especially height (figures 1 and 2).

Lung diffusion also increased in both sexes with increasing TLC (figure 3 and 4); however, such relationship was not noticed with DLco/VA. Multiple linear regression analysis was used to test the power of DLco prediction depending on different combinations of body size parameters (height, weight, BSA). Height was the single best DLco predictor than other combinations of body size parameters.

Table (1): Physical characteristics and pulmonary function parameters (mean ± SD) of (20) boys and (16) girls aged 13-19 year.

Sex		Mean	Std. Deviation	Min-Max
Age (year)	Boys	16.10	2.04	13-19
	Girls	16.18	2.0	13-19
Height (cm)	Boys *	170.50	6.21	162-181
	Girls	157.31	6.52	146-170
Weight (Kg)	Boys *	63.4	11.30	47-90
	Girls	52.6	7.83	38-66
BSA (m2)	Boys *	1.68	0.19	1.4-2.1
	Girls	1.42	0.12	1.2-1.6
FVC (L)	Boys *	4.32	0.87	3.2-5.8
	Girls	3.10	0.68	2.3-4.7
$FEV_{1\%}$	Boys *	90.4	5.6	80-100
	Girls	86.25	5.75	80-99
$MMEF_{25-75\%}$ (L/S)	Boys *	4.14	0.69	3.0-5.4
	Girls	3.47	0.58	2.25-4.5
TLC (L)	Boys *	5.97	1.24	4.0-7.5
	Girls	4.38	0.65	3.5-5.5
DLco(ml/min/mmHg)				
	Boys *	31.58	6.67	20-40
	Girls	23.93	3.12	19-32
DLco/VA(ml/min/mmHg/L)				
	Boys	1.85	0.12	1.6-2.0
	Girls	1.78	0.17	1.5-2.0

*** Significant at *P* level < 0.01.**

Table (2): Correlation coefficient values (r) for DLco in relation to physical characteristics of subjects and TLC

	Age	Height	Weight	BSA	TLC
DLco (Boys) n=20	0.67 P<0.01	0.89 P<0.01	0.70 P<0.01	0.85 P<0.01	0.86 P<0.01
DLco (Girls) n=16	0.36 NS	0.82 P<0.01	0.40 NS	0.37 NS	0.72 P<0.01

- **Correlation considered not significant at P level > 0.05.**
- **Prediction Equations for DLco: DLco = constant + (height X height coefficient).**
- **For boys: Dlco = -132.0 + (Height X 0.96).**
- **For girls: DLco= -38.14 + (Height X 0.40).**

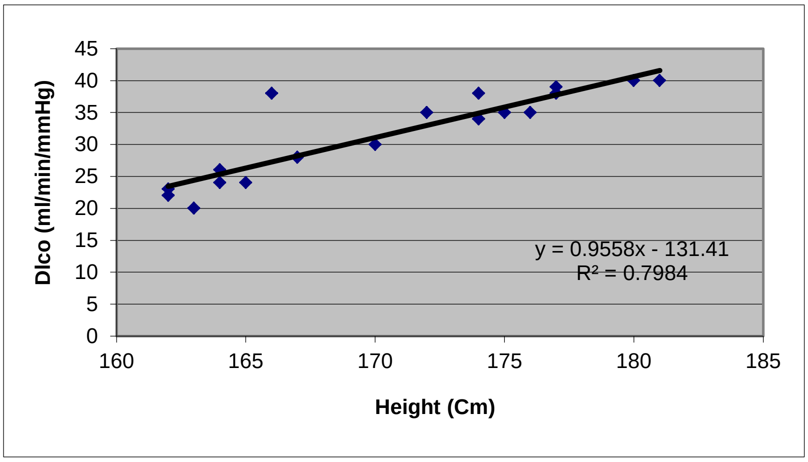

Figure (1): Lung diffusion capacity in relation to height in (20) adolescent boys.

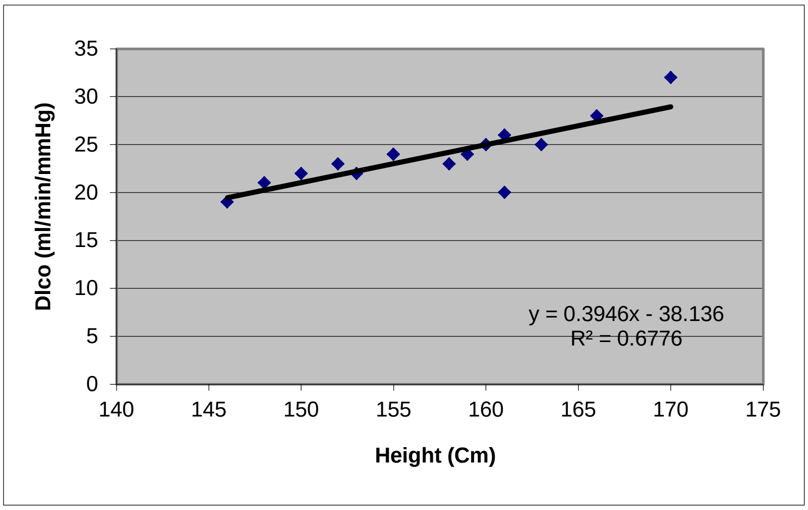

Figure (2): Lung diffusion capacity in relation to height in (16) adolescent girls.

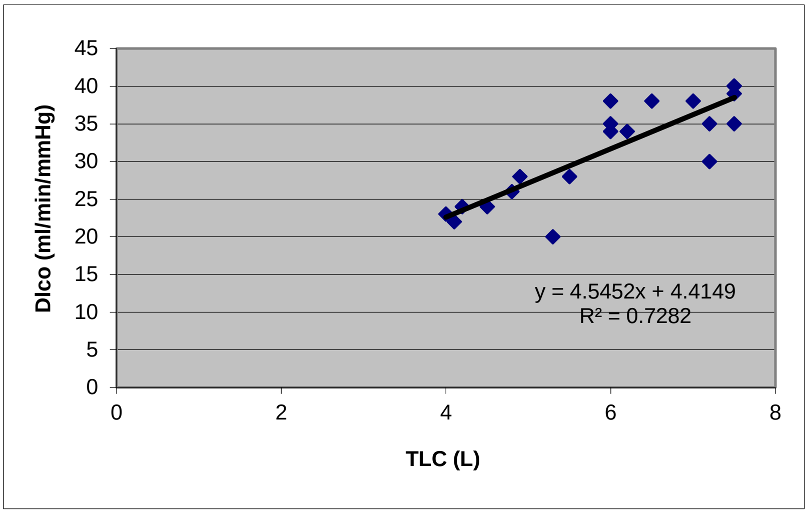

Figure (3): Lung diffusion capacity in relation to TLC in (20) adolescent boys.

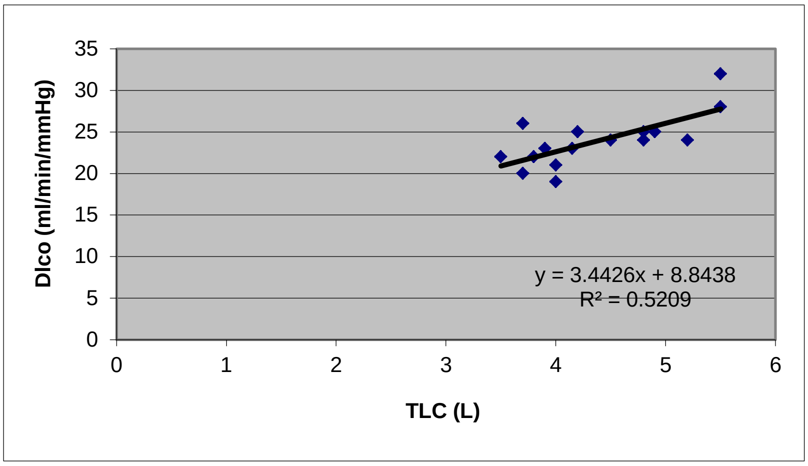

Figure (4): Lung diffusion capacity in relation to TLC in (16) adolescent girls.

DISCUSSION

Pulmonary function test values are influenced by anthropometric, environmental, genetic, ethnic, socio-economic and technical variations. Thus, each laboratory carrying out these investigations must establish its own normal standards for the population under investigation.

In actual fact, only a few function tests have been covered in selected groups and the differences in methodology used don't always make the results comparable. A great need, therefore, exist to collect more data in normal individuals in order to bridge up these gaps in our knowledge.

The DLco values observed in the present study group of healthy adolescents were comparable to Asians,[4,5] but lower than those of western studies.[8,9,10] Such differences has also been pointed by Corre *et al* and recommended to subtract (15%) from western normals for application to Asians.[11] This difference could be explained at least in part to nutritional factors which could also influence growth and function of body organs directly or through hormonal effect thus influencing body size and hence the size of lung.[12] In clinical practice, the introduction of specific values for lung diffusion capacity in relation to lung volume (DLco/VA) is controversial. Some studies reported an independence of DLco/VA ratio on body height [5,13] in contrast to Cotes *et al* who observed a decrease of DLco/VA ratio with increase in body height [8] which suggested a decrease in alveolar gas exchange per unit of lung size in the lungs of older than in younger children.

Results of the present study revealed independence of DLco/VA as a function of height which is in agreement with De Muth *et al* study.[13] The DLco values in boys were significantly higher than girls (table 1). This sex difference in DLco cannot be attributed solely to sex with out the effect of lung volume factor which was significantly higher in boys (table 1).

However, other factors could be blamed like difference in the level of physical activity and in social patterns of life[14, 15] possibly by increasing the power of inspiratory muscles or by altering the mechanical properties of the chest wall so increasing the TLC.[9]

The present results is also in agreement with Gibson's study in considering that many of the normal gender differences in respiratory function result from differences in body size but, even after taking in account of size, important differences in certain tests remain, for example, after adolescence the vital capacity and total lung capacity of males exceeds those of females.[16,17]

The similarity for DLco/VA between both sexes has also been reported by other studies.[8, 18] Gender differences in transfer factor and its subdivision reflects the difference in lung size assuming that the proportion of the alveolar wall occupied by alveolar capillaries is the same for both.

In addition, the ratio Dm/Vc is the same in boys and girls and not materially different from the value found in adult.

This finding is an evidence that the relationship of the diameters of the alveolar capillaries to the thickness of their walls is unaffected by growth.

By contrast, the DLco/VA decrease during childhood which suggests that growth takes place in the interstices between the capillaries to a great extent than in the gas-exchanging portion of the respiratory membrane.

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