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PREDICTION EQUATION FOR LUNG FUNCTIONS IN SOUTH INDIAN CHILDREN

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Abstract : Lung functions including VC, IVC, FVC, $FEV_{0.5}$, FEV_1, PEF, $FEF_{0.2-1.2}$, $FEF_{25-75\%}$, $FEF_{75-85\%}$, PIF, FMFT, MVV_{IND}, peak expiratory flow at 25%, 50% and 75% of FVC, peak inspiratory flow at 75%, 50%, 25% and the ratio between different lung volumes were measured with Vitallograph Compact-II spirometer on 109 South Indian school boys in the age group of five to sixteen years. The results show an increase in "lung volumes" and "flow rates" with increase in age, height and weight. FMFT and MVV_{IND} also increase with increase in anthropometric measurements. All the lung functions except $FEF_{75-85\%}$ and the ratio between different lung volumes show significant positive correlation with age, height and weight. Regression equations were derived for predicting normal lung functions for healthy South Indian boys. Lung volumes and flow rates were lower than North Indian and foreign boys. The decrease in lung functions in South Indian boys were due to their sea level dwelling, dietary habits and comparatively lower anthropometric measurements.

Key words : lung volumes flow rates boys

INTRODUCTION

The differences in lung function in normal population may be due to ethnic origin, physical activity, environmental conditions, altitude, age, height, sex and socio-economic status (1). Lung function test is regarded as an essential component in the medical evaluation of patients with respiratory disorders (2). Studies on lung function test were more confined to parameters viz., FVC, FEV_1 and PEFR (3, 4, 5, 6, 7). By the advent of applied physiological branches such as occupational physiology, sports physiology and other allied branches, it become more essential to have reference standard for lung function indices. There is a need for establishing regression equations to predict lung volumes and flow rates on a regional basis for a comparative study in a sub-continent like India. The present study is to report normal

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lung volumes and flow rates in healthy South Indian boys along with their prediction equations.

METHODS

109 healthy boys from Government High School, Trissur, Kerala aged between 5 to 16 years were selected and was grouped into 4. They were mostly from higher and middle income groups living at sea level with rice as their staple diet. Children with recurrent upper or lower respiratory infections, physically and mentally handicapped and low income group were excluded from this study. Age, height and weight were recorded. Lung functions were measured with a portable PC based precalibrated frequently checked spirometer with printer (Vitallography Compact II, Buckingham). Respiratory function tests were carried out during morning hours. The test is reproducible and valid for all age groups. The techniques were demonstrated to each child and they were made 3-5 efforts while standing and wearing a noseclip. The best of the multiple trials was recorded automatically by the machine at BTPS (body temperature, ambient pressure and saturated with water vapour) and was chosen for analysis.

Spirometric indices measured were vital capacity (VC), inspiratory vital capacity (IVC), forced vital capacity (FVC) forced expiratory volume at 0.5 second ($FEV_{0.5}$), ratio between forced expiratory volume at 0.5 second to forced vital capacity expressed as % ($FEV_{0.5}$/FVC%), forced expiratory volume at 1 second (FEV_1), ratio between FEV_1/VC%, FEV_1/IVC% and FEV_1/FVC% respectively, peak expiratory flow (PEF), peak expiratory flow 200-1200 ($FEF_{0.2-1.2}$), forced mid expiratory flow ($FEF_{25-75\%}$), forced mid flow time (FMFT), peak expiratory $flow_{75-85\%}$ ($FEF_{75-85\%}$), peak expiratory flow at 25%, 50% and 75% of FVC ($FEF_{25\%}$, $FEF_{50\%}$, $FEF_{75\%}$), peak inspiratory flow (PIF), peak inspiratory flow at 75%, 50% and 25% ($FIF_{75\%}$,$FIF_{50\%}$,$FIF_{25\%}$), maximal voluntary ventilation(MVV_{IND}). Vital capacity and inspiratory vital capacity were recorded by doing separate manoeuvre. All other measurements were obtained while the subject performed a forced vital capacity manoeuvre.

The results were statistically analysed. Pearsonian coefficient of correlation and 't' value for lung functions and physical measurements were calculated. Multiple regression equation for predicting indices of lung functions from age and height were derived.

RESULTS

Table I shows the mean values of physical measurements and lung volumes in healthy boys. Height and weight showed gradual increase from 5-7 to 14-16 years of age group. Lung volumes viz., VC, IVC, FVC, $FEV_{0.5}$, FEV_1 showed steady increase from lower age group to upper age group. $FEV_{0.5}$/FVC%, FEV_1/VC%, FEV_1/IVC% and FEV_1/FVC% showed fluctuating results with physical measurements in the present study.

Table II indicates mean values of physical measurements and flow rates. The expiratory flow rates viz., PEF, $FEF_{0.2-1.2}$, $FEF_{25-75\%}$, $FEF_{75-85\%}$, $FEF_{25\%}$, $FEF_{50\%}$ and $FEF_{75\%}$ showed gradual increase with age, height and weight. Inspiratory flow rates

TABLE I : Mean values and standard deviation (SD) of physical measurements and "lung volumes" in healthy South Indian boys aged 5-16 years.

Age group years	*n*	*Mean height±SD (cm)*	*Mean weight±SD (kg)*	*VC±SD (1)*	*IVC±SD (1)*	*FVC±SD (1)*	*$FEV_{0.5}$±SD (1)*	*$FEV_{0.5}$/FVC%±SD*	*FEV_1±SD (1)*	*FEV_1/VC%±SD*	*FEV_1/IVC%±SD*	*FEV_1/FVC%±SD*
5 - 7	18	119.00±7.16	18.25±2.88	1.14±0.21	1.09±0.23	1.16±0.18	0.91±0.12	78.17±7.92	1.07±0.18	94.49±7.03	100.18±11.40	92.68±5.14
8 - 10	16	130.70±4.17	24.06±1.47	1.47±0.14	1.44±0.16	1.49±0.11	0.94±0.18	68.30±2.47	1.26±0.11	85.40±4.96	87.60±5.24	83.60±3.77
11 - 13	33	142.84±4.52	31.38±3.57	2.05±0.13	1.87±0.10	2.04±0.06	1.46±0.13	72.08±1.50	1.79±0.11	85.18±2.99	100.50±8.09	87.67±3.35
14 - 16	42	159.21±6.25	44.64±6.84	2.45±0.41	2.31±0.50	2.42±0.50	1.91±0.27	72.00±4.53	2.26±0.37	89.32±6.21	107.56±8.17	90.24±5.01

TABLE II : Mean values and standard deviation (SD) of "flow rates" in healthy South Indian boys aged 5-16 years.

PEF±SD (1/min)	$FEF_{0.2-1.2}$±SD (1/s)	$FEF_{25-75\%}$±SD (1/s)	FMFT±SD (s)	$FEF_{75-85\%}$±SD (1/s)	$FEF_{25\%}$±SD (1/s)	$FEF_{50\%}$±SD (1/s)	$FEF_{75\%}$±SD (1/s)	PIF±SD (1/s)	$FIF_{75\%}$±SD (1/s)	$FIF_{50\%}$±SD (1/s)	$FIF_{25\%}$±SD (1/s)	MVV_{IND}±SD (1/min)
121.17±8.90	1.76±0.13	1.64±0.05	0.34±0.07	0.77±0.18	2.25±0.15	1.85±0.14	1.15±0.11	1.95±0.10	1.71±0.27	1.90±0.18	1.76±0.21	38.33±5.71
179.80±16.80	2.29±0.21	1.82±0.11	0.37±0.01	0.76±0.08	2.28±0.34	2.28±0.24	1.36±.06	2.23±0.09	1.91±0.09	2.22±0.12	2.10±0.10	46.20±2.99
222.17±25.33	2.99±0.40	2.56±0.36	0.42±0.08	0.79±0.14	3.39±0.18	2.40±0.30	1.37±0.22	2.70±0.39	2.23±0.15	3.10±0.47	2.98±0.26	67.08±5.95
260.85±56.44	3.83±0.80	2.71±0.28	0.46±0.09	0.84±0.09	4.13±0.71	3.06±0.24	1.85±0.07	3.51±0.49	2.70±0.14	3.57±0.39	3.02±0.28	79.52±9.02

viz., PIF, $FIF_{75\%}$, $FIF_{50\%}$ and $FIF_{75\%}$ increase with age, height and weight. FMFT and MVV_{IND} also increase with increase in physical parameters.

TABLE III : Correlation coefficients of physical measurements and lung functions in healthy South Indian boys aged 5-16 years.

Measurement	Correlation coefficient		
	Age	Height	Weight
VC (I)	0.829*	0.837*	0.859*
IVC (I)	0.822*	0.892*	0.897*
FVC (I)	0.799*	0.824*	0.748*
$FEV_{0.5}$ (I)	0,895*	0.929*	0.884*
$FEV_{0.5}$/FVC%	0.017	0.140	0.140
FEV_1 (I)	0.853*	0.844*	0.822*
FEV_1/VC%	0.056	0.015	0.037
FEV_1/IVC%	0.331**	0.316**	0.278
FEV_1/FVC%	0.074	0.137	0.166
FEF (1/min)	0.748*	0.773*	0.619*
$FEF_{0.2-1.2}$ (1/s)	0.731*	0.764*	0.680*
$FEF_{25-75\%}$ (1/s)	0.717*	0.709*	0.617*
FMFT (s)	0.409*	0.340*	0.311*
$FEF_{75-85\%}$ (1/s)	0.113	0.213	0.183
$FEF_{25\%}$ (1/s)	0.927*	0.787*	0.652*
$FEF_{50\%}$ (1/s)	0.774*	0.772*	0.466*
$FEF_{75\%}$ (1/s)	0.693*	0.704*	0.561*
PIF (1/s)	0.744*	0.717*	0.702*
$FIF_{75\%}$ (1/s)	0.830*	0.833*	0.805*
$FIF_{50\%}$ (1/s)	0.816*	0.794*	0.805*
$FIF_{25\%}$ (1/s)	0.855*	0.826*	0.761*
MVV_{IND} (1/min)	0.847*	0.839*	0.774*

*P<0.01
**P<0.05

All the lung functions except $FEF_{75-85\%}$ showed a significant positive correlation with age, height and weight (P<0.01). $FEV_{0.5}$/FVC%, FEV_1/VC% and FEV_1/FVC% were not significantly correlated with age, weight and height. FEV_1/IVC% showed a positive correlation at 5% level (P<0.05) with age and height but insignificant with weight (Table III).

The multiple regression equations for healthy South Indian boys based on age and height are shown in Table IV. Predicted lung function indices can be derived from these regression equations.

TABLE IV : Regression relationship for predicting indices of lung function from age (yrs) and height (cm) in healthy South Indian boys.

VC	=	$-5.621 + (0.088 \times a) + (0.044 \times b)$
IVC	=	$1.174 + (0.027 \times a) + (0.0021 \times b)$
FVC	=	$-3.526 + (0.168 \times a) + (0.023 \times b)$
$FEV_{0.5}$	=	$-1.980 + (0.018 \times a) + (0.022 \times b)$
FEV_1	=	$-1.045 + (0.090 \times a) + (0.012 \times b)$
PEF	=	$-83.490 + (1.2 \times a) + (1.971 \times b)$
$FEF_{0.2-1.2}$	=	$-1.211 + (0.073 \times a) + (0.024 \times b)$
$FEF_{25-75\%}$	=	$-0.420 + (0.0796 \times a) + (0.013 \times b)$
FMFT	=	$0.298 + (0.0159 \times a) - (0.0005 \times b)$
$FEF_{25\%}$	=	$3.35 + (0.320 \times a) - (0.027 \times b)$
$FEF_{50\%}$	=	$-0.191 + (0.072 \times a) + (0.013 \times b)$
$FEF_{75\%}$	=	$-0.296 + (0.0378 \times a) + (0.009 \times b)$
PIF	=	$-0.028 + (0.132 \times a) + (0.0091 \times b)$
$FIF_{75\%}$	=	$0.522 + (0.063 \times a) + (0.0072 \times b)$
$FIF_{50\%}$	=	$-1.475 + (0.134 \times a) + (0.02 \times b)$
$FIF_{25\%}$	=	$0.008 + (0.122 \times a) + (0.008 \times b)$
MVV_{IND}	=	$-41.24 + (3.285 \times a) + (0.447 \times b)$

a – age in years
b – standard height in cm

DISCUSSION

Establishing regression equations to predict various measurements of normal lung function on a regional basis in a country like India, with wide variations in geographical, climatic, dietary habits and ethnic origin, is important for the management of patients with various cardio-pulmonary diseases (8). The aim of this study was to derive reference values of lung function in South Indian boys aged between 5-16 years and to compare with other ethnic groups. Results of lung function studies in normal children are available for North Indian children (3,4,9). In South India, reference for lung function values regarding PEFR are only available (7,10). All the previous studies were confined to limited measurements. There was no previous reports on twenty two lung function indices which can be used clinically as well as in other applied branches of physiology.

In the present study it can be seen that lung volumes are much lower than foreign authors (11,12,13). Malik *et al* (3) and others (4,9) reported higher lung volumes in northern children than in the present study. This could be due to higher anthropometric measurements observed in the earlier studies (3,4,9). There was a wide variation in PEFR as reported by various workers in South Indian children whose values were higher than the present one (7,10). Faridi et al (6) reported lower FC, FEV_1 and PEFR values which could be due to the technical reasons as small children do not cooperate properly. FMFT, subdivisions of inspiratory and expiratory flow rates were not discussed due to the absence of previous works.

Our observations suggest that there are important differences in lung functions between races. In particular, it appears that lung functions are lower in South Indian boys than boys belong to other parts of India and their foreign counterparts. The FEV_1, had ethnic differences similar to those of VC but varies less among racial groups. This means that there were considerable variations in FEV_1/VC. Changes in airway size or in the elastic recoil of the lung affect FEV_1. The factors that determine PEF are predominantly the efficiency of expiratory muscle, elastic recoil pressure of lung and airway size. Thus almost all the ethnic differences in ventilatory lung function appeared to be due to differences in lung size at full inspiration (1). Large differences in lung function between Indians and White people were attributed to a shorter chest length in Indians which is a racial characteristic (12). Mathur et al (14) also observed that all the values of ventilatory functions are lower as compared to American and Swedish figures. They further stated that this may be due to the comparatively small structure of Indians along with other racial and climatic factors.

The lung function values might be related to the way of life. Lakhera and Kain (5) reported superior lung functions in highland boys than low landers and concluded that size of the lung is governed by genetic, environmental and nutritional factors and confirmed that physical training during growth may help in developing a greater endurance in respiratory muscles. Woolcock et al (1) found that ventilatory functions were higher in females and children living in highlands than the costal population. It is possible that increased physical activity, by increasing the power of the inspiratory muscles or by altering the mechanical properties of the chest wall, increases VC by increasing total lung capacity (TLC). Physical activity must commence in childhood or adolescence to produce significant differences (1). Though the measurements of TLC were not made in this study, the large ethnic differences in VC and FEV_1 can be explained in terms of differences in TLC. Total lung capacity may vary because of differences in sizes of chest cage or mechanical properties of the chest cage. The respiratory status of childen is influenced by the nutritional status (15, 16). The lower lung function indices in South Indian boys may be due to their dietary habits, sea level dwelling and comparatively lower anthropometric measurements.

This study reports positive and strong correlations between age, height, weight and various indices of lung function except $FEF_{75-85\%}$. Lung volumes and flow rates increase with increase in age, height and weight. Earlier reports show significant relation between age, height and lung functions (3,9,12,13). Chetty et al (4) reported that vital capacity was highly correlated with age, height and weight. They revealed that age, height and weight will lead to better lung function prediction than anyone. Roizin et al (11) propounded that FEV_1/FVC was not related to anthropometric measurements. The present study shows that $FEF_{75-85\%}$, $FEF_{0.5}/FVC\%$, $FEV_1/VC\%$ and $FEV_1/FVC\%$ was not related to physical measurements. Only the $FEV_1/IVC\%$ had significant relation with age and height but not the weight.

In conclusion we have presented reference data for healthy South Indian boys aged 5-16 years. The study has shown that lung function values were lower than North Indian and other foreign children. In the present study, lung functions increase with increase in age, height and weight. The decrease in lung function levels in South Indian boys were due to their sea level dwelling, dietary habits and comparatively lower anthropometric measurements. From the present study, we recommend further active research to establish individual population based regression equations to predict lung volumes and flow rates.

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