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PREDICTION EQUATIONS FOR MAXIMAL VOLUNTARY VENTILATION IN NON-SMOKING. NORMAL SUBJECTS IN MADRAS

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Abstract : Maximal voluntary ventilation (MVV) was measured in 256 healthy non-smoking adults (132 males, 124 females) aged 15-63 years living in Madras. The mean MVV (±SD)in males was 126.7±31.9 and in females 77.7±16.4. Regression equations were derived for men and women for predicting maximal voluntary ventilation for adults in South India. MVV in South Indians were similar to those reported for other Indian subjects, but lower than those reported for caucasions.

Key words: maximal voluntary ventilation pulmonary function test

INTRODUCTION

Maximal voluntary ventilation (MVV) is defined as the maximal volume of gas which the subject can ventilate per minute (1). The measurement of WV is made during voluntary hyperventilation and the frequency of breathing should be at least 80/minute. We had earlier reported regression equations for men and women for predicting normal pulmonary function (spirometry, lung volumes and diffusing capacity) for young adults in South India(2). However, there are not many studies especially from South India to derive regression equation for predicting MVV (3-5). The aim of the present study was, therefore, to establish regression equations for predicting MVV in non-smoking healthy subjects residing in Madras.

METHODS

We studied 256 non-smoking South Indians (132 males and 124 females) living in Madras (aged 15-63 years). They included relatives of patients attending the Tuberculosis Research Centre, staff members, manual workers and executives, to obtain a cross section of the normal inhabitants of Madras city. The proportion of subjects who declined to take part in this study was less than 1%. Subjects were eligible for the study if they were ethnic South Indians, had no structural deformity of the thoracic cage and were free from respiratory infections, and had been so for at least three months before the test. None of the subjects had any cardiorespiratory disease, as assessed by detailed history, physical examination, chest radiography and 12 lead electrocardiography.

Maximal Voluntary Ventilation : Maximal Voluntary Ventilation was carried out with Transfer Test Model C (PK Morgan, Chatham, UK), readings being obtained from a Data Dec Computer. Sex, ethnic identity, standing height to the nearest centimeter without shoes, weight in kilograms, ages smoking habit, occupation and spirometer temperature were recorded for all subjects before testing. The tests were carried out with the subjects seated. The equipment was calibrated each day. The coefficient of variation of six subjects studied over one year was less than 5% for MVV. Maximal Voluntary Ventilation was recorded by asking the subject to breathe in and out as rapidly and deeply as possible for 6 seconds (6). At least two consistent readings were obtained for each subject and the highest value in litres/minute was used for analysis.

Statistical methods : Best fitting cross sectional equations were derived separately for men and women by multiple linear regression analysis. Age, height and weight were entered into the equation for MVV. Age, height and weight interactions were tested for significance by means of stepwise regression procedure. Residuals were

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calculated and tested for each of these best fining models for each sex. The goodness of fit of the models was also tested by examining correlations of residuals with age, height and weight and by inspectings groups of residuals versus predicted values to confirm the absence of a curvilinear pattern.

All analysis were performed with the SPSS/PC statistical computing package on an IBM/XT compatible personal computer. Unless otherwise stated the term significant is used to imply a P value of less than 0.05.

RESULTS

The mean (SD) height was 166.1(7.7) cm in men and 151.8 (5.8) cm in women, and weight was 56.0(12.7) and 45.7 (9.1) kg. In men, the mean PVC was 3.42 (0.64) litres, FEV_1 2.92 (0.60) litres and FEV_1/FVC % 85 (7.2) ; in women the mean was FVC 2.30 (0.35) litres. FEV_1 1.99 (0.31) litres and FEV_1/FVC % 86.8 (6.4).

Both height and weight in men showed significant positive correlations with MVV. In women. height had significant positive correlation with MVV (Table I). Correlations of MVV with flow volume loop measurements in both sexes are shown in Table II.

The multiple regression equations for men and women (age group 15-63 years) based on age, height and weight are shown in Table I. In order to eliminate the influence of growth during adolescence and to have homogenous groups, separate regression equations were derived for the age groups 15-20 years and 21-55 years in both sexes and the results are shown in Table III. Regression equations

TABLE I : Regression equations for predicting maximal voluntary ventilation from age (yr), height (cm) and weight (kg) in healthy South Indians (Age group 15-63 yr.)

Measurement	Mean	SD	constant	*Regression co efficients*			*Multiple*	*Standard*	*Correlation coefficients*		
				Age	*Height*	*Weight*	*R*	*Error*	*Age*	*Height*	*Weight*
Males											
MVV	126.7	31.9	–168.688	– 0.579	1.775	0.130	0.336	44.304	–0.122	0.555**	0.410**
Females											
MVV	77.7	16.4	–33.470	– 0.338	0.712	0.323	0.413	15.061	–0.145	0.238*	0.184

MVV = Maximal Voluntary Ventilation (Litres/minute) ; *P<0.01, *P<0.001

TABLE II : Correlation of MVV with flow-volume loop measurements

	FVC	FEV_1	PEFR	$FEF_{25-75\%}$	V_E25%	V_E50%	V_E75%
Males	0.65*	0.74*	0.73*	0.70*	0.66*	0.66*	0.57*
Females	0.37*	0.45*	0.31*	0.38*	0.31*	0.36*	0.32*

*P<0.001
MVV : Maximal Voluntary Ventilation, FEV_1: Forced Expiratory Volume in 1 second, PEFR : Peak Expiratory Flow Rate, FEF25-75% : Forced Expiratory Flow at middle half of vital Capacity, VE 25%, VE50%, VE 75% : Flow rates at 25%, 50% and 75% of forced vital capacity (FVC).

TABLE III: Regression equations for predicting MVV (Litres/minute) for age groups 15-20 years and 21-55 years from age (yr) height (cms) and weight (kg).

Age *groups*	*Mean*	*SD*	*Constant*	*Regression coefficients*			*Multiple*	*Standard*
				Age	*Height*	*Weight*	*R*	*Error*
15-20 yr.								
Males (n = 45)	121.8	39.8	–329.836	5.558	2.132	0.013	0.724	27.988
Females (n:20)	76.3	17.8	–99.019	0.423	0.932	0.610	0.439	17.475
21-55 yr								
Males (n = 84)	128.8	35.4	–107.571	–0.895	1.422	0.521	0.544	24.684
Females (n = 102)	78.6	16.3	–17.250	–0.718	0.679	0.334	0.466	14.609

for the age group above55 years were not derived because of small numbers in this group. Predicted values are derived from the regression equations as follows.

Predicted values = K+ (age in years x age coefficient) + (standing height in Cms x height coefficient) + (weight in kg x weight coefficient).

Where K is the constant.

The predicted values of maximal voluntary ventilation obtained from these regression equations for subjects of specified age (30 years), height (165 cms for men, 155 cms for women) and weight (55 kg for men, 45 kg for women) are compared with those from other studies in Table IV. Indirect maximal breathing capacity derived from for predicted value of FEV_1 (2) is also shown in Table IV.

TABLE IV : Predicted values of MVV (L/Minute) in men (30yr, 165 cm, 55 kg) and women (30 yr, 155 cm, 45 kg).

	Men	*Women*
Kamat et al (W. India)	116	58
Jain et al (N. India)	125	84
Cotes (Caucasian)	162	99
Bass (Caucasian)	140	117
Vijayan (S. India)		
(a) MVV	114	76
(b) IMBC	105	76

MVV = Maximal Voluntary Ventilation
IMBC = Indirect Maximal Breathing Capacity

DISCUSSION

Establishment of regression equations for predicting maximal voluntary ventilation is essential for proper evaluation of cardiorespiratory stress testing especially for calculation of dyspnoeic index in various cardio-respiratory diseases (1). Our findings in both men and women in this study are similar to those reported in North Indian subjects (3,4). Although similar in men, it was higher in women compared to western Indian females (5). Our values were nearly 30% and 25% less in males and females respectively on comparison with those of Caucasians (1.7).

The significant positive correlations of MVV with height and weight in males and with height in females in this study were similar to those reported in earlier studies (3, 5). MVV had the highest positive correlation with FEV_1, a finding similar to the previous studies (1). Because of the highest correlation of MVV with FEV_1, an indirect measurement known as indirect maximal breathing capacity (IMBC) can be derived from the formula, FEV 0.75 multiplied by 40 (1, 8). Since FEV_1 is the most commonly measured spirometric index in any pulmonary function laboratory, FEV 0.75 can be derived from the relationship FEV 0.75 = 0.92 FEV_1 - 0.07 (8). This relationship is independent of ethnic group and can be applied to children as well as adults (1). The observation that indirect MBC derived using FEV 0.75 from our previous prediction equation for FEV_1(2), is similar to the direct MVV in this study supports the validity of our regression equation.

It had been observed that MVV was reduced in direct proportion to the degree of weakness of respiratory muscles in malnourished patients (9). The determination of MVV may therefore, be of use in the assessment of chronic lung diseases associated with malnutrition (10), as the relationship of malnutrition with chronic lung disease is being increasingly realised (11).

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