SPIROMETRIC VOLUMES IN MALAYSIAN MALES

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Abstract. Spirometry was performed on 1,485 male subjects ranging in age from 13 years to 78 years and comprising of all the main ethnic groups in Malaysia. They were divided into six age categories. Mean forced vital capacity (FVC) and forced expiratory volume in 1 second (FEV_1) were 3.45 ± 0.02 and 3.10 ± 0.02, respectively. Both FVC and FEV_1 correlated negatively with age. Regression analysis revealed an age-related decline in FVC of 295 ml per decade of life. Multiple stepwise regression of the data for the prediction of an individual's FVC above the age of 20 years gave the equation FVC (1) = 0.0404 (height in cm)-0.0295 (age in years)-2.2892. Predicted FVC values derived from equations based on other populations were considerably higher than the observed mean in this study. This study therefore, reemphasises the need to be cautions when applying formulae derived from one population to another. Grossly erroneous conclusions may be reached unless predicted equations for lung-function tests for a given population group are derived from studies based upon the same population group.

INTRODUCTION

A number of reference values for spirometry have been published over the years. Most of these have dealt with Europeans (Berglund *et al,* 1963; Cotes *et al,* 1966; CECA, 1983; Roca *et al,* 1986; Paoletti *et al,* 1986; Oxhj *et al,* 1988), North American populations (Kory *et al,* 1961; Cherniack and Raber, 1972; Dockery *et al,* 1985) and Indians from the Indian sub-continent (Rao *et al,* 1961, Cotes and Malhotra, 1964; Jain and Ramiah, 1969; Chatterjee *et al,* 1988). A few studies have also been made on Asian Chinese (Wu and Yang, 1962; Chuan and Chia, 1969; Da Costa, 1971) and other non-caucasians (Johannsen and Erasmus, 1968; Dufétel *et al,* 1989). These however have been obtained with various methods and some have been based on studies of specific groups of individuals. There have been few reports of similar studies in the Malaysian population, which comprises three main ethnic groups, namely Malays, Chinese and Indians. and these have been limited to a few screening tests on small groups of subjects (Chan and Raman, 1968; Singh *et al,* 1989). In view of the paucity of normal data availability on Malaysian males a further statistically analyzed study of pulmonary functions in healthy Malaysian males seemed relevant as very little can be gleaned from studies of Chan and Raman (1968) and Singh *et al* (1989) in terms of forming a reliable reference standard for the Malaysian population.

The present study therefore aimed to determine the lung function parameters in normal healthy Malaysian males and to ascertain whether there are differences between the lung function measurements of Malaysian and those of other population groups. An attempt was also made to derive reliable prediction formulae for lung volumes in the Malaysian subjects. A comparison of the predicted values for Malaysian males using formulae derived from this study and those derived from other studies was also made.

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MATERIALS AND METHODS

A total of 1,486 healthy male volunteers (34% smokers, 61% nonsmokers and 5% ex-smokers), ranging from 13 years to 78 years in age and living on the Island of Penang participated in this study. The study sample was derived from the general population consisting of all the main ethnic groups in Malaysia, and from as wide a socio-economic stratum as possible. They were divided into six age-categories [Group A (13-19 years); Group B (20-29 years); Group C (30-39 years); Group D (40-49 years); Group E (50-59 years) and Group F (60-78 years)].

The subjects completed a modified MRC questionnaire (1986) on respiratory symptoms, past medical history, smoking and occupational history and only those considered to be in good heatlh at the time of the study were included. None had chronic bronchitis as defined by the Medical Research Council (1965). Age was recorded to the nearest year. Height was measured with the subject standing barefoot to the nearest 0.5 cm using a standiometer and weight was recorded (in light street clothes) to the nearest 0.5 kg.

Forced expiratory volume in one second (FEV_1) and forced vital capacity (FVC) were measured with a rubber rolling seal volume-displacement dry spirometer (Vicatest VCT, Mijnhardt) which has been shown to have a good correlation with the Stead-Wells water-sealed spirometer (Wever *et al,* 1981). The Stead-Wells spirometer is recommended as the reference spirometer by the Committees on Environmental Health and Respiratory Physiology of the American College of Chest Physicians (1975). The spirometers were calibrated with the same calibrator before and after each day's measurements. FEV_1% (FEV_1 expressed as percentage of FVC) was also calculated. For the measurement of FEV_1 and FVC each subject was asked to inhale deeply in the standing position and with the nose clamped, blow rapidly and as completely as possible for at least six seconds into a previously calibrated spirometer. The procedure was explained and demonstrated to each subject. Subjects were encouraged to attain maximum effort and three measurements were made at 1-minute intervals. The average of the two highest measurements was taken as the most representative of the subject's capacity. FVC and FEV_1 readings were corrected to body temperature and pressure saturated with water vapor (BTPS).

Mean values with their standard error of mean (SEM) were calculated for the whole group and for age categories. Statistical analysis was performed using Student's *t*-test, analysis of variance (ANOVA) and by linear regression analysis. Statistical significance was accepted at $p<0.05$ or less.

RESULTS

No statistically significant differences were evident in the lung functions or anthropometric variables between the three ethnic groups. The data was therefore pooled for further statistical analysis and the derivation of prediction formulae.

The anthropometric data for the subjects are presented in Table 1. Analysis of variance revealed significant differences in height and weight between the different age groups ($p<0.001$ and $p<0.001$ respectively), height being significantly lower and weight significantly higher in the older age groups.

Pulmonary functions as assessed by FEV_1, FVC and FEV% revealed a progressively lower value with advancing age groups (Table 2). Forced vital capacity in group F was 38.5% lower than in group A (Table 2). Similarly, FEV_1 and FEV_1% too were found to be significantly lowered with age ($p<0.001$) (Table 2).

The correlation coefficients between the various anthropometric and lung function parameters are

Table 1

Mean values and standard error of mean of age, height and weight by age groups in male Malaysians.

	A 13-19 (n=264)	B 20-29 (n=466)	C 30-39 (n=414)	D 40-49 (n=199)	E 50-59 (n=106)	F >60 (n=37)	Total (A-F) 13-78 (n=1,486)
Age (yrs)	16.6 ±0.1	24.1 ±0.1	34.2 ±0.1	44.2 ±0.2	52.3 ±0.2	65.8 ±1.3	31.4 ±0.3
Height (cm)	166.4 ±0.5	168.7 ±0.3	166.3 ±0.3	165.9 ±0.5	163.9 ±0.6	163.6 ±1.2	166.8 ±0.2
Weight (kg)	55.1 ±0.5	61.0 ±0.4	65.6 ±0.5	66.1 ±0.8	66.1 ±1.3	65.1 ±2.1	62.4 ±0.3

shown in Table 3. FVC and FEV_1 were highly significantly correlated with age and with height. FEV_1% revealed a significant but weak negative correlation, with age and weight.

Stepwise multiple regressions, for ages 13-78, were also used in determining the 'best' subsets of the anthropometric variables for the prediction of lung function parameters. In calculating the equations for the regression of lung function with age, a curvelinear regression based on the natural log ($\log_e$) was used and is tabulated in Table 4 together with the residual standard deviation (RSD) and its significance (p). The data were also divided into two groups, for derivation of prediction equations, one comprising of subjects between the ages 13-19 years and the other between 20-78 years. This was done so because it is already apparent that in the young age group (13-19 years) lung volumes are little influenced by age but markedly influenced by body size. Hence, simplified linear models could than be used to predict lung function indices (FVC and FEV_1) in the two groups. None of the lung function indices were significantly associated with weight. The reference equations obtained from the linear model for the younger age group and the adult age group are tabulated in Table 5.

DISCUSSION

Given the scarcity of information concerning lung parameters from this region, this report presents lung function parameters and prediction equations derived from a large sample of a general healthy Malaysian male population. Although the subjects were mainly from the Island of Penang, their ethnic mix and span over a wide socioeconomic stratum could be considered to represent a sample of a typical Malaysian population.

Analysis of lung function data shows that mean forced vital capacity of 3.45 ± 0.021 (Table 2) for a mean age of 31.4 years (Table 1) in this study was higher than that observed in males from South India (Kamat *et al,* 1967), but within the range of values reported from selected populations of India (Chatterjee *et al,* 1988), Nepal (Bangham and Veale, 1976) and of West Pakistani workers in the United Kingdom (Malik *et al,* 1972). FVC was

Table 2

Means and standard error of mean of lung parameters by age groups in male Malaysians.

	A 13-19 (n = 264)	B 20-29 (n = 466)	C 30-39 (n = 414)	D 40-49 (n = 199)	E 50-59 (n = 106)	F > 60 (n = 37)	Total (A-F) 13-78 (n = 1,486)
FEV_1 (l)	3.46 ± 0.04	3.43 ± 0.03	2.99 ± 0.03	2.69 ± 0.04	2.32 ± 0.06	2.05 ± 0.08	3.10 ± 0.02
FVC (l)	3.53 ± 0.05	3.81 ± 0.03	3.42 ± 0.03	3.14 ± 0.04	2.76 ± 0.06	2.31 ± 0.09	3.45 ± 0.02
FEV_1(%)	99.3 ± 0.8	90.2 ± 0.3	87.6 ± 0.3	85.9 ± 0.6	84.3 ± 0.8	89.2 ± 1.7	90.1 ± 0.3

Table 3

Correlation coefficients between the variables in male Malaysians (13-78 years). Asterisk indicates the level of statistical significances at $p < 0.001$.

	FVC	FEV_1	FEV_1%	Age	Height	Weight
FVC	1.00	0.90*	-0.11*	-0.44*	0.52*	0.16*
FEV_1		1.00	0.33*	-0.58*	0.48*	0.05
FEV_1%			1.00	-0.37*	0.02	-0.22*

Table 4

Logarithmic regression equations for the ages 13-78 years for male Malaysians with residual standard deviations (RSD) and the significances (p).

	13-78 years
FVC	$\log_e FVC = 2.294 + 0.561 \log_e A - 0.025A - 366.186/H$ RSD = 0.45, $p < 0.001$
FEV_1	$\log_e FEV_1 = 2.906 + 0.264 \log_e A - 0.019A - 350.697/H$ RSD = 0.51, $p < 0.001$

H, height (cm); A, age (years).

Table 5

Linear regression equations and residual standard deviations (RSD) for male Malaysian teenagers (13-19 years) (A) and male Malaysian adults (20-78 years) (B).

	A: 13-19 years	B: 20-78 years
FVC	$FVC = 0.054H + 0.0498A - 6.273$ RSD = 0.33, $p < 0.001$	$FVC = 0.0404H - 0.0295A - 2.2892$ RSD = 0.45, $p < 0.001$
FEV_1	$FEV_1 = 0.043H + 0.0528A - 4.501$ RSD = 0.33, $p < 0.001$	$FEV_1 = 0.0355H - 0.0311A - 1.8229$ RSD = 0.49, $p < 0.001$

H, height (cm); A, age (years).

however, lower than that observed in age matched European (Berglund *et al,* 1963; Cotes and Malhotra 1964; CECA, 1983; Roca *et al,* 1986; Paoletti *et al,* 1986), American (Cherniack and Raber, 1972; Miller *et al,* 1986) and Senegalese (Dufétel *et al,* 1989) males. The precise reason for this difference is uncertain although it has been attributed to both genetic and environmental factors (Cotes *et al,* 1975). Anthropometric variations may explain some of these differences as the physical stature of Westerners on the average is somewhat larger than that of the Asians.

Further comparison of our lung function data by age categories with data from other Asian and African studies show contrasting differences. Our data are comparable to those reported for Indian (Jain and Ramiah, 1969), African (Johannsen and Erasmus, 1968) and Trinidadian (Edwards *et al,* 1972) males but lower than those for Nepalese (Bangham and Veale, 1976), Indian (Jain and Gupta, 1972), New Guinean (Cotes *et al,* 1973) and Guyanian (Miller *et al,* 1970) populations and higher than data from South Indian (Kamat *et al,* 1967) males. The precise reason for these differences is uncertain although they may be attributable to methodological or ethnic differences.

Lung function appeared to be progressively lower with increasing age category, particularly from the fourth decade of life onwards (Table 2). A significant negative correlation was evident with age (Table 3). Height and weight were found to correlate positively with FVC. Age related decline in lung function has been reported by a number of investigators (Kory *et al,* 1961; Berglund *et al,* 1963; Da Costa, 1971; Paoletti *et al,* 1986). Some age related changes in the musculoskeletal components of the thoracic-abdominal compartments have been suggested to contribute to this decline and in this respect a decline in maximal respiratory pressures has been reported in both the males and females, particularly in those over 55 years in age (Black and Hyatt, 1969).

Regression analysis revealed an age related decline in FVC of 295 ml per decade in our subjects between the age of 20 and 78 years (Tables 5). This is somewhat higher than the rates of decline between 105 to 270 ml per decade reported by others (Berglund *et al*, 1963; Miller *et al*, 1970; Da Costa, 1971; Cherniack and Raber, 1972; Roca *et al*, 1986; Paoletti *et al*, 1986; Miller *et al*, 1986; Oxhj *et al*, 1988; Chatterjee *et al*, 1988), although a decline of 340 ml per decade has also been reported (Malik *et al*, 1972). This age-related trend is further illustrated in Fig 1, where we have plotted the predicted FVC for males 167 cm in height from the age of 20-70 years using prediction formulae derived from other populations. The exact reason for this difference in the rate of decline in FVC with age between this and other studies is unclear although the present material is the largest set studied in this region representing a bigger cross-section of the population of different ages and also larger than the studies referred to in this paper and may therefore be more reflective of the age associated change in FVC.

Variations in both FVC and FEV_1 within a population, varying in age from 13 to 78 years, can also be decribed by a single curvelinear equation (Table 4). However, to ease their handling in a daily clinical routine, we have also derived separate prediction formulae for individuals between the ages of 13 to 19 years and between the ages of 20 to 78 years (Table 5). Statistical analysis of data again showed that separation of teenagers and adults permitted simplified equations without loss of predictive accuracy. Subsequent comparision of predicted values from these formulae and actual measurements revealed no significant differences,

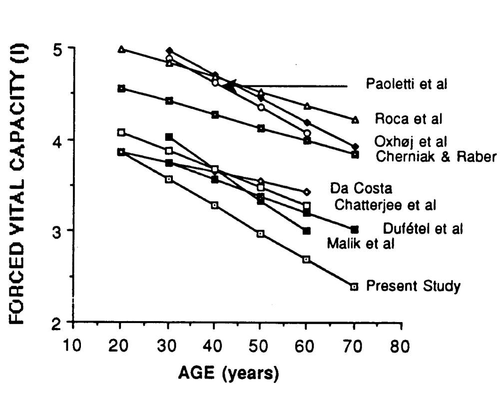

Fig 1—Predicted forced vital capacity for males 167 cm in height of various ages using published equations.

indicating therefore that both linear and curvelinear equations can be used for the prediciting FVC and FEV_1 values (Table 6).

Comparison of predicted values (for a 35 year old male measuring 167 cm in height, mean age and height of the 20 to 78 age group) using age and height standardized equations from data of different populations with the observed mean in this study revealed consistently higher predicted values (Table 7). The predicted values were 5% to 49% greater than the observed mean in the present study. The biggest differences were found when using formulae based on data from males of European or American descent (Kory *et al*, 1961; Berglund *et al*, 1963; Cherniak and Raber, 1972; Roca *et al*, 1986; Paoletti *et al*, 1986; Miller *et al*, 1986; Oxhj *et al*, 1988). It is interesting to note that although the formulae were corrected for age and height, the predicted values for a given age and height were higher than the observed mean in our study. This is in contrast to the observations of Chan and Raman (1968) who in their report, based on a small group of Malaysian subjects, found no difference between their observed mean and that predicted using formulae from western populations. The reason for this discrepancy is not immediately apparent. Nevertheless the large difference between the observed mean and that predicted from formulae based on data from European or American males reemphasises the need to be cautions when applying formulae, derived from one population to another. Besides, it also further reinforces the need for population groups to form their own population norms for the various physiological parameters.

In conclusion, this study shows that both FVC and FEV_1 were lower in Malaysians when compared to Europeans. Similar trends have also been seen for Indian, Chinese and African subjects (Rao *et al*, 1961; Wu and Yang, 1962; Johannsen and Erasmus 1968; Chuan and Chia, 1969; Da Costa, 1971; Chatterjee *et al*, 1988). This difference was present even when the effects of variation in age, height and weight were eliminated. It is unlikely that this is due to poor nutrition or health as all the subjects in this study were adequately nourished and healthy. Genetic, ethnic and environmental factors could possibly influence these parameters (Cotes *et al*, 1975). The difference notwithstanding, this study provides useful norms, based on a large sample derived from the local population, for clinicians in this region. In addition, it appears

Table 6

Comparision of actual mean measurements of FVC and FEV_1 with that obtained using either logarithmic regression equation or linear regression equation of a randomly selected 115 subjects.

n=115	Actual value	Value obtained using logarithmic regression equation	Value obtained using linear regression equation
FVC (l)	3.03±0.07	3.02±0.05	3.09±0.05
FEV_1 (l)	2.74±0.06	2.75±0.05	2.71±0.05

Table 7

Comparison of predicted values using regression equations, for males with residual standard deviation (RSD), from other studies with the observed mean in the present study for a male 167 cm in height (H) 35 years of age (A).

Ref	n	FVC=	RSD	Predicted mean for a male 167 cm in height and 35 years in age	Observed mean in this study	Predicted mean minus observed mean	% difference
Berglund *et al*	296	0.048H-0.020A-2.21	0.50	5.11	3.43	1.68	49%
Oxhj *et al*	240	0.062H-0.026A-4.60	0.52	4.84	3.43	1.41	41%
Roca *et al*	443	0.0678H-0.015A-6.04	0.53	4.76	3.43	1.33	39%
Paoletti *et al*	59	0.0724H-0.027A-6.39	0.58	4.76	3.43	1.33	39%
Kory *et al*	468	0.052H-0.022A-3.60	0.58	4.31	3.43	0.88	26%
Cherniack and Raber	870	0.048H-0.014A-3.18	-	4.35	3.43	0.92	27%
Jain and Ramiah	188	0.044H-3.313	0.49	4.04	3.43	0.61	18%
Chatterjee *et al*	104	0.049H-0.020A-3.699	0.48	3.78	3.43	0.35	10%
Chuan and Chia	50	0.048H-0.0156A-3.80	0.38	3.67	3.43	0.24	7%
Da Costa	134	0.0409H-0.0105A-2.761	0.55	3.70	3.43	0.27	8%
Johannsen and Erasmus	120	0.0375H-2.835	0.45	3.43	3.43	-	-
Dufetal *et al*	282	0.0451H-0.018A-3.25	0.48	3.65	3.43	0.22	6%
Malik *et al*	371	0.066H-0.034A-5.98	-	3.85	3.43	0.42	12%
Miller *et al*	96	0.044H-0.024A-2.90	0.46	3.61	3.43	0.18	5%
Present study	1,222	0.0404H-0.0295A-2.2892	0.45	3.43	3.43	-	-

that for purposes of predicting lung functions for an individual it is always better to use equations derived from the same race or population sample.

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