VENTILATORY FUNCTION IN NORMAL INDUSTRIAL MALAY WORKERS IN SINGAPORE

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SYNOPSIS

Results of ventilatory function measurements in a study of 69 healthy Malay male industrial workers from two factories in Singapore have been presented.

The analysis of the data suggests that in these subjects the FEV_1 and FVC are related to age and height ($p<0.01$) as uniformly reported in other studies.

When the regression equations of this present study were compared with other studies, the Caucasians had higher mean FEV_1 and FVC while the Indians had lower values than the Malays. The African and the Chinese have rather similar ventilatory functions to the Malays. However, if occupational activities have an influence on ventilatory function, then it would be likely that the Chinese have higher ventilatory function than the Malays.

This findings confirm many of the previous studies which reported on the differences in ventilatory function in various racial groups.

In addition, this study presents the ventilatory function data in the form of prediction nomograms for the FEV_1 and FVC in the normal adult Malay workers thus enabling rapid and convenient derivation of normal values.

INTRODUCTION

Differences in ventilatory function in various racial groups have been noted in the literature and repeatedly commented upon. Studies of the vital capacity in Asian (Wu *et al,* 1962; Poh *et al,* 1969; Da Costa *et al,* 1971) and African (Johannsen *et al,* 1968) population groups showed that it was invariably lower than in Caucasian subjects even after allowing for the effects of variation in age, height and weight.

However, no studies have been made on Malay subjects and extrapolation from the results of the European or Chinese studies would be unreliable and unsatisfactory.

Further, many studies have been carried out to determine the relationship between the strenuousness of occupations or athletic prowess to lung volumes among healthy young men. Stuart *et al* (1959) compared 20 athletes and 20 non athletes and found that the mean vital capacity score of the athletes was significantly higher than the mean non athlete vital capacity, but insignificant differences existed between the two groups in maximum breathing capacity (MBC) and the MBC/VC ratio. He suggested that the difference in vital capacity is due to increased development of respiratory musculature incidental to regular physical training. Shapiro *et al* (1962) found that athletic conditioning was associated with an increased vital capacity. Thus in the assessment of ventilatory function among the industrial workers there is a need to consider the role of physical activity when considering normal reference values.

The purpose of this study therefore was to obtain normal values for ventilatory capacity (the one second forced expiratory volume, FEV_1 and forced vital capacity, FVC) in healthy subjects of Malay origin involved in moderate work which implies standing, light or moderate work at machine or bench (Schilling, 1973).

MATERIALS AND METHODS

A representative random sample of the general population of Malay workers in Singapore would be almost impossible to attain. Indeed, in the available literature, few attempts have been made at the random selection of the experimental subject from any defined population group.

Sixty-nine male Malay workers, aged between 16 and 60 years from two factories—a printing press factory and a metal container factory were selected for the study from the medical records of all the male Malay production workers in these two factories and comprised all the workers in the two factories who met the criteria listed below.

The criteria used for acceptance as a 'normal' subject were:

1. no history of cardiopulmonary disease;
2. no evidence of cardiopulmonary disease in a normal chest roentgenogram within 6 months prior to the testing;

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3. no evidence or history of disease which could influence pulmonary function with a normal clinical examination of the cardiopulmonary system;
4. capacity to co-operate adequately during the tests;
5. engaged in moderate work for at least 6 months and with no history of previous exposure to any occupation which is known to influence pulmonary function.

Using these criteria, sixty nine male Malay workers were accepted as normal. A history of smoking would not be a reason for the exclusion of the subject and smoking habits were recorded so that the subjects could be categorised into 3 groups according to their smoking habits. Non smokers were those who, at no time in their life, had smoked or were ex-smokers. Since only healthy men were included in the study, the ex-smokers would not have given up smoking because of chest illness and their inclusion would therefore be unlikely to bias the results. As cigarettes come in packets of 10, light to moderate smokers were defined as those who smoked less than 10 cigarettes per day and heavy smokers were those who smoked more than 10 cigarettes per day.

Age was recorded to the nearest completed year; standing height was measured, with the subject barefooted, to the nearest completed half a centimeter. Sitting height was not used in this study because, being more difficult to measure, it is much more subject to error. Further, Ferris *et al* (1965) demonstrated that the extra refinement of determining sitting height does not appreciably change the prediction formulae of FEV_1 and FVC. Weight (in light street clothing without shoes) was recorded to the tenth of a kilogram.

The ventilatory function tests, namely FEV_1 and FVC, were done on a Vitalograph Spirometer. Vitalographs are supplied with a certificate of calibration, rendering each instrument identical with another in each measurement.

The effects of diurnal variation in ventilatory function was minimised by testing the subjects only during the day from 10 am to 3 pm. As all these workers were not exposed to any hazard which would influence their pulmonary function during the shift, they were tested at random times during the course of their shift.

The purpose of the test was explained to each subject by one of the authors (ZKO) and the method of testing was demonstrated. Every effort was made to allay apprehension and achieve co-operation.

The test was conducted with the subject in standing position; nose clips were not used. They were urged to take a maximal inspiration and then blow down the spirometer tube as hard and as fast and as completely as possible. The best of 3 readings was accepted, after the subject was fully conversant with the technique. All the volumes were corrected to body temperature, ambient pressure and saturated with water vapour (BTPS).

RESULTS

The sample consisted of 69 male Malay workers (Table I). They were all production workers involved in moderate work. Table II shows the smoking habits of these workers.

The mean values, standard deviation and coefficient of variation for the physical characteristics and each of the physiological measurements of the subjects are presented in Table III.

An electronic calculator was used to develop a correlation matrix (Table IV) based on the variables measured.

Height demonstrates consistent positive correlation with FEV_1 and FVC ($p < 0.01$) while age shows a consistent negative correlation with both respiratory function measurements ($p < 0.01$). In this study height and age show a consistently higher correlation with both the ventilatory function measurements than does weight. Height and weight are positively interrelated; this is reflected in the positive correlation found between them and when the effect of height is eliminated, the correlation of weight with the ventilatory function measurements (FEV_1 and FVC) is not significant ($p > 0.01$). An almost perfect correlation is found between FEV_1 and FVC ($r = 0.94$).

Since age and height consistently showed the highest correlation with FEV_1 and FVC, these two parameters were chosen for deriving prediction formulae for the two pulmonary function measurements.

The partial regression coefficients and constants required in the regression equations to predict a value of FEV_1 and FVC for a given age and height are shown in Table V, together with the respective multiple correlation coefficients 'R' and the standard error of estimate 'SEE'.

TABLE I

AGE DISTRIBUTION OF WORKERS

Age group in years	No.	%
16 - 19	11	15.9
20 - 24	12	17.4
25 - 29	11	15.9
30 - 34	10	14.5
35 - 39	11	15.9
40 - 44	7	10.1
45 - 49	4	5.8
$\geqslant 50$	3	4.4
Total	69	99.9

TABLE II

SMOKING HABITS OF WORKERS

No. of cigarettes smoked per day	No.	%
current non-smokers	24	34.8
<10	21	30.4
>10	24	34.8
Total	69	100.0

For the three categories of smokers the mean FEV_1 standardized to the average age and height of the whole group were respectively 2.95, 3.08 and 3.17 litres, while the FVC were 3.40, 3.55 and 3.60 litres. The adjusted mean FEV_1 and FVC show a tendency to increase as the amount smoked increases but the difference between the smoking category is small and was not statistically significant. The three groups have therefore been combined to yield the overall regressions shown in Table VI.

Prediction nomograms (Figs. 1 and 2) were then constructed from the regression equations so that the value for FEV_1 and FVC may be read off directly.

Table VII shows a series of multiple correlation coefficients ('R') of some other authors for comparison with the present series. This is to give some idea of how well the other studies fit the source data as 'R' assesses the extent to which the data are described by the relationship.

The 'R' values from this study are lower than those of Cotes *et al* (1966) but are comparable with the other studies (Kory *et al*, 1961; Poh *et al*, 1969 and Da Costa *et al*, 1971). These differences were not explicable in terms of differences in the formulation of the equations and they are probably due to differences in the actual performance of the subjects during the tests.

Comparisons between the present study consisting of healthy Malay industrial workers and previous studies regarding prediction formulae are shown in Tables VIII and IX which indicate the differences between the predicted mean and the observed mean values. The mean values of height and age from the present study were substituted in the formulae of previous studies in calculating the predicted mean. The observed means are those that were calculated for the sample of the present study. The difference between the predicted and observed means permitted comparison of the different prediction formulae. As the original data from the other studies were not available, it is not possible to test these differences statistically.

DISCUSSION

The analysis of the data suggests that in these subjects the FEV_1 and FVC are related to age and height ($p < 0.01$). This had been reported in many previous studies (Kory *et al*, 1961; Da Costa *et al*, 1971). In fact, John Hutchinson had, as early as 1846, commented that vital capacity was directly related to height and inversely proportional to age (cited by Kory *et al*, 1961). The relationship can be described with reasonable precision by a linear multiple regression equation. However, caution must be exercised in applying these equations. There is evidence that the decline in ventilatory capacity with age may not be quite linear as is implied in existing regression equations (Schilling, 1973).

Bearing in mind the limitation of all prediction formulae, it is apparent that regression equations still provide a useful yardstick for the comparison of ventilatory function measurements.

When the prediction regression equations of this present study are compared with other studies, the Caucasians have higher values for FEV_1 and FVC than the Malays while the Indians have lower values. However, the Chinese in Da Costa's study and the African have rather similar ventilatory function to the Malays.

Both Da Costa's study and this present study were conducted in Singapore. However, it must be noted that the two populations were not really comparable in the sense that the workers in this study are engaged in some form of physical activity, being industrial workers, unlike the Chinese in Da Costa's study which consists mainly of Chinese engaged in

TABLE III

PHYSICAL CHARACTERISTICS AND LUNG FUNCTION DATA IN THE MALAYS BY SMOKING HABITS

Measurements	current non smokers				< 10 cigarettes/day				> 10 cigarettes/day			
	No. of subjects	Mean	S.D.	coefft of variation	No. of subjects	Mean	S.D.	coefft of variation	No. of subjects	Mean	S.D.	coefft of variation
Age (yrs)	24	30.7	11.00	35.8	21	28.4	8.76	30.8	24	33.0	10.55	31.9
Ht. (cm)	24	162.7	5.25	3.2	21	165.5	6.46	3.9	24	162.9	6.86	4.2
Wt. (kg)	24	57.1	9.44	16.5	21	63.3	24.00	37.9	24	54.9	7.10	12.9
FEV_1 (1)	24	2.91	0.48	16.3	21	3.23	0.54	16.7	24	3.09	0.64	20.6
FVC (1)	24	3.35	0.40	11.9	21	3.70	0.56	15.2	24	3.53	0.65	18.5

TABLE IV

CORRELATION BETWEEN PHYSICAL DATA AND LUNG FUNCTION MEASUREMENTS

Measurement	Age	Height	Weight	FEV_1	FVC
Age	1.00				
Height	N.S.	1.00			
Weight	N.S.	0.59	1.00		
FEV_1	—0.58	0.66	0.35+	1.00	
FVC	—0.49	0.72	0.48+	0.94	1.00

All the correlation coefficients shown are significant at the 1% level.

N.S. = correlation coefficients not significant ($p > 0.01$).

+ = $p < 0.01$ before effect of height was eliminated but $p > 0.01$ after elimination of the effect of height.

TABLE V

PARTIAL REGRESSION COEFFICIENTS AND CONSTANTS FOR THE REGRESSION EQUATIONS OF FEV_1 AND FVC ON AGE AND HEIGHT BY SMOKING CATEGORIES

Measurements	Regression coefficients		Constant	Multiple correlation coefficient (R)	Standard error of estimate (SEE)
	Age (yrs)	Height (cm)			
current non smokers					
FEV_1	— 0.012	+ 0.044	— 3.83	0.64	0.38
FVC	— 0.003	+ 0.045	— 3.92	0.62	0.33
< 10 cigarettes/day					
FEV_1	— 0.029	+ 0.041	— 2.70	0.75	0.37
FVC	— 0.023	+ 0.059	— 5.42	0.81	0.35
> 10 cigarettes/day					
FEV_1	— 0.033	+ 0.048	— 3.64	0.87	0.32
FVC	— 0.031	+ 0.053	— 4.13	0.88	0.32
All 3 categories by smoking habits					
FEV_1	— 0.023	+ 0.049	— 4.17	0.77	0.36
FVC	— 0.017	+ 0.056	— 5.07	0.77	0.36

TABLE VI

REGRESSION EQUATIONS FOR FEV_1 AND FVC

FEV_1	=	0.048 Ht — 0.024 Age — 3.98 (R = 0.78; SEE = 0.35)
FVC	=	0.056 Ht — 0.017 Age — 5.13 (R = 0.78; SEE = 0.34)

sedentary jobs. If occupational activities have an influence on ventilatory function then it would appear that if comparable groups are studied, the Chinese would be likely to have higher ventilatory function than the Malays.

Further, Cotes (1974) had pointed out that "for the practice of respiratory medicine there is a need to bear in mind the predominant role of environmental factors when considering normal reference values".

It would appear, therefore, that physical activity, in addition to racial differences should be considered in the assessment of ventilatory function. The present study was thus carried out to establish normal values for respiratory function measurement of FEV_1 and FVC in healthy workers of Malay origin involved in physical activity. Prediction nomograms were constructed from the regression equations so that the values of FEV_1 and FVC could be read off directly.

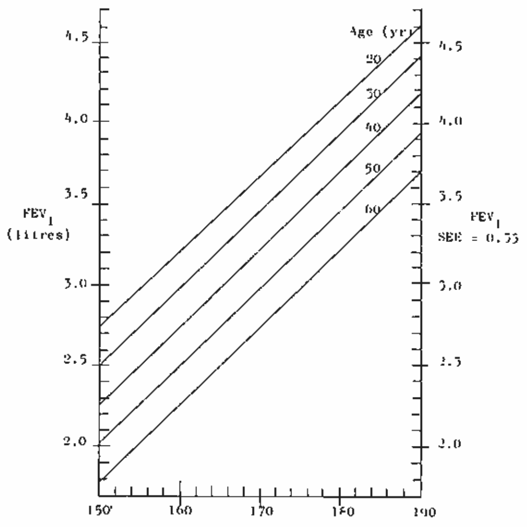

Fig 1 : FEV_1 for normal adult male Malay workers in Singapore

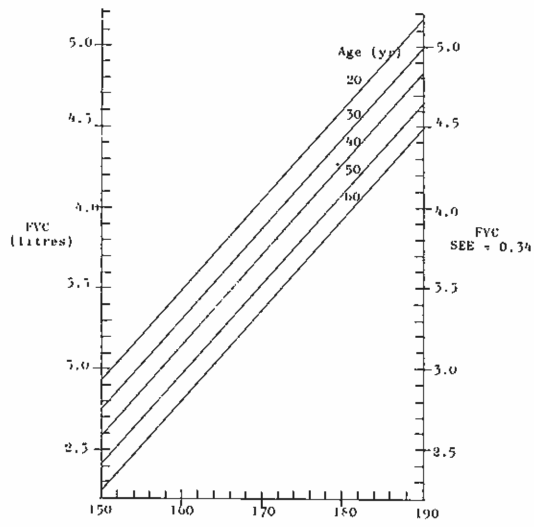

Fig 2 : FVC for normal adult male Malay workers in Singapore

TABLE VII

COEFFICIENT OF MULTIPLE CORRELATION 'R' FOR THE PRESENT STUDY COMPARED WITH THOSE OBTAINED FROM OTHER STUDIES

Ventilatory Measurements	Cotes *et al*		Kory *et al*		Da Costa *et al*		Poh *et al*		present study	
	No. of subjects	'R'	No. of subjects	'R'	No. of subjects	'R'	No. of subjects	'R'	No. of subjects	'R'
FEV_1	275	0.83	468	0.63	134	0.70	50	0.62 (FEV 0.75)	69	0.77
FVC	275	0.82	468	0.64	134	0.55	50	0.66 (V.C.)	69	0.77

TABLE VIII

COMPARISON OF PREDICTION FORMULAE OF FEV_1 FOR MALAY WORKERS USING MEAN VALUES FOR AGE AND HEIGHT FROM PRESENT STUDY

Investigator	original case material with no. of subjects	Prediction Formulae	S.E.E.	predicted mean in litres	observed* mean in litres	predicted —observed mean
Da Costa *et al*	Chinese (Singapore) (134)	0.0267 Ht—0.0189 Age—0.774	0.33	3.01	3.07	—0.06
Kory *et al*	American (468)	0.037 Ht—0.028 Age—1.59	0.52	3.61	3.07	+0.54
Cotes *et al*	British (275)	0.0346 Ht—0.033 Age—1.12	0.45	3.53	3.07	+0.46
Miller *et al*	African (96)	0.034 Ht—0.024 Age—1.82	0.37	3.01	3.07	+0.06
Miller *et al*	Indian (129)	0.034 Ht—0.024 Age—1.98	0.37	2.85	3.07	—0.22

* observed mean is that of present authors.

TABLE IX

COMPARISON OF PREDICTION FORMULAE OF FVC FOR MALAY WORKERS USING MEAN VALUES FOR AGE AND HEIGHT FROM PRESENT STUDY

Investigator	original case material with no. of subjects	Prediction Formulae	S.E.E	predicted mean in litres	observed* mean in litres	predicted — observed mean
Da Costa *et al*	Chinese (Singapore) (134)	0.0409 Ht — 0.0105 Age — 2.761	0.55	3.61	3.52	+ 0.09
Kory *et al*	American (468)	0.052 Ht — 0.022 Age — 3.60	0.58	4.23	3.52	+ 0.71
Cotes *et al*	British (275)	0.0508 Ht — 0.032 Age — 3.02	0.52	4.31	3.52	+ 0.79
Miller *et al*	African (96)	0.044 Ht — 0.024 Age — 2.90	0.46	3.56	3.52	+ 0.04
Miller *et al*	Indian (129)	0.044 Ht — 0.024 Age — 3.07	0.46	3.39	3.52	— 0.13

* observed mean is that of present authors.

ACKNOWLEDGEMENTS

The authors wish to thank:

The management and workers of the factories without whose whole hearted cooperation this study could not have been undertaken.

Dr. M. L. Thomson and Miss J. Walford of the TUC Centenary Institute of Occupational Health, University of London for their valuable help and advice.

NO H. A. Mae, Staff Nurses H. L. Pang, Veronica Chung and K. H. Liew of the Industrial Health Department for participating in the study.

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