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Spirometry in healthy elderly Chinese

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ABSTRACT Forced expiratory volume (FEV_1), forced vital capacity (FVC), and peak expiratory flow (PEF) were measured in healthy subjects (129 men, 210 women) aged 60 years and above who were leading an independent and active life in the community. Women but not men showed an age related decline in FEV_1 and FVC. Correlations of FEV_1 and FVC with height were weaker than those reported for all age groups. Male ex-smokers had lower FEV_1 values than current smokers and non-smokers. Regression equations are derived for men and women for predicting values appropriate to Chinese elderly people. These values are slightly lower than those for white people, but the difference is not as great as in values derived from surveys of all age groups.

Introduction

Measurements of lung function in the elderly have shown in general that values are lower than in younger age groups,[1 2] although it is not clear whether this represents a physiological decline or a result of environmental factors.[3] Correlations between spirometric indices and age or height are weaker than in younger age groups,[1] and there are discrepancies between the results of different studies. Burr *et al* showed a decline in FEV_1 and FVC with age in both smokers and non-smokers,[2] but Milne and Williamson found this association only in women.[1] Racial differences have also been observed in studies of lung function at all ages.[4 5] Little information is available regarding lung function in the elderly except in white people.

In a study of lung function in ethnic Chinese in Singapore, only 26 subjects were aged 60 years or more[6 7] and in the study of Ching and Horsfall on lung function in normal Hong Kong Chinese (mostly Cantonese) none of the subjects was over 56 years.[8] In the largest study of all age groups among Hong Kong Chinese 332 of the 3490 subjects were over 65 years.[4] The results may be biased, however, as it included only volunteers from selected institutions.

A survey of the health of elderly subjects living in sheltered housing in an urban area of Hong Kong was carried out by the Chinese University of Hong Kong. We therefore had a unique opportunity to measure lung function in normal, healthy subjects drawn from all over Hong Kong without the potential bias introduced by recruiting only volunteers from institutions. The aim of this study was to establish spirometric values for normal, healthy Chinese elderly people aged 60 years or more in this broadly based sample of the population.

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Methods

Sheltered housing consists of flats provided by the government shared by up to six elderly people, interspersed between flats owned by other members of the community.[9] The criteria of entry are that the applicant should be capable of self care and able to lead an independent, active life. All subjects were Chinese, 87% of them originating from southern China, like most of the Hong Kong population. They came from all regions of Hong Kong, which consists of an area of 1068 square kilometres with a population of 5·6 million (Hong Kong Government census, 1985). Eleven per cent of the respondents were still employed. Before admission to the sheltered housing scheme all applicants underwent a medical examination, including chest radiography. Those found to have serious disease were excluded from the scheme.

In this study subjects were first interviewed on the basis of a detailed health questionnaire, which included questions derived from the Medical Research Council questionnaire on respiratory symptoms.[10] The response rate was 96%; the main reason for refusal was fear of venepuncture, which formed part of our survey. Forced expiratory volume in one second (FEV_1), forced vital capacity (FVC), and peak expiratory flow (PEF) were measured with a Compact spirometer (Vitalograph Ltd). As this was a community study a light weight portable spirometer was chosen. After initial coaching, at least three measurements were made by an experienced technician. Unsatisfactory curves were rejected and the best of three readings was used, according to the recommendations of the American Thoracic Society.[11] All measured values were converted to BTPS. Height and weight were measured with subjects in light clothing and without shoes. Data from 46 subjects were found to meet the MRC criteria for chronic bronchitis and six subjects with haemoptysis were excluded in the calculation of regression equations for predicting values for various age groups. Results were coded, entered into a computer, and analysed by the Statistical Analysis System (SAS). Pearson's correlation coefficient was used to examine the association between lung function, age, and height, and Wilcoxon's rank sum test was to compare lung function in smokers and non-smokers.

In comparing lung function between different subjects of different age groups, we standardised FEV_1 and FVC to the overall mean height for men and women using the following equation (FEV_1* indicating standardised FEV_1):

$$FEV_1^* = \frac{FEV_1}{Height^2} \times \text{mean height}^2.$$

FVC standardised to the overall mean height for men or women was derived in the same way.

Results

After exclusion of 46 subjects with chronic bronchitis and 12 subjects with unsatisfactory recordings, measurements from 129 men and 210 women were analysed. Among the men, 47% were current smokers, 38% ex-smokers and 15% non-smokers. Among the women, 20% were current smokers, 22% ex-smokers, and 58% non-smokers. Their age, height, body mass index, FEV_1, FVC, and PEF are shown in table 1. In women FEV_1 and FVC correlated positively with height and negatively with age, the association being stronger for height (table 2). In men FEV_1 and FVC were correlated positively with height only.

Tables 3 and 4 show lung function measurements standardised to an overall mean height of 1·61 m for men and 1·49 m for women in four different age groups, and regression equations of standardised FEV_1 (FEV_1*) and standardised FVC (FVC*) on age. Age related decline in FEV_1 and FVC was observed in women only.

Male ex-smokers had a lower mean FEV_1* than non-smokers and current smokers, and non-smokers and current smokers had similar FEV_1* values (table 5). No difference was found between the three smoking categories among women. When the effect of age on FEV_1* in smokers and non-smokers was examined, only the regression line for ex-smokers was significantly different from horizontal ($y = -0.045x + 4.45$; $p < 0.001$, SE slope 0·01, SD 0·37).

Table 6 shows the regression equations for men and women, which may be used to calculate predicted values based on age and height. For FEV_1 and FVC

Table 2 *Correlation coefficients between lung function, age, and height*

	PEF	FEV_1	FVC	FEV_1/FVC (%)
MEN (n = 129)				
Age	0·002	−0·06	−0·158	0·11
	NS	NS	NS	NS
Height	0·115	0·175*	0·281*	−0·08
	NS	$p < 0.05$	$p < 0.001$	NS
WOMEN (n = 210)				
Age	−0·018	−0·186*	−0·189*	−0·039
	NS	$p < 0.01$	$p < 0.01$	NS
Height	0·118	0·358*	0·372*	0·027
	NS	$p < 0.001$	$p < 0.001$	NS

*Statistically significant.
Abbreviations as in table 1.

Table 1 *Height, body mass index, and spirometric indices (mean (SD) values) of the subjects*

Age (y)	n	Height (m)	BMI (kg/m²)	FEV_1 (l)	FVC (l)	FEV_1/FVC (%)	PEF (l/min)
MEN							
60–64	17	1·61 (0·07)	21·70 (3·14)	1·67 (0·50)	2·70 (0·69)	61·9	253 (104)
65–69	42	1·62 (0·05)	21·07 (3·23)	1·78 (0·57)	2·79 (0·84)	63·8	302 (113)
70–74	54	1·60 (0·09)	21·95 (4·67)	1·76 (0.57)	2·63 (0.69)	66·9	284 (106)
75+	16	1·60 (0·05)	22·15 (3·60)	1·64 (0·55)	2·45 (0·76)	66·9	300 (109)
All men	129	1·61 (0·07)	21·72 (3·92)	1·74 (0·55)	2·67 (0·75)	65·2	288 (101)
WOMEN							
60–64	26	1·50 (0·06)	23·82 (4·55)	1·54 (0·31)	2·11 (0·46)	73·0	232 (77)
65–69	71	1·49 (0·06)	22·31 (4·21)	1·46 (0·44)	2·06 (0·56)	70·9	214 (69)
70–74	78	1·49 (0·07)	22·63 (4·29)	1·29 (0·40)	1·82 (0·51)	70·9	211 (70)
75+	35	1·48 (0·07)	22·66 (4·48)	1·37 (0·29)	1·97 (0·31)	69·5	229 (78)
All women	210	1·49 (0·07)	22·72 (4·20)	1·39 (0·40)	1·96 (0·51)	70·9	218 (71)

BMI—body mass index; FEV_1—one second forced expiratory volume; FVC—forced vital capacity; PEF—peak expiratory flow.

Table 3 *Standardised lung function measurements (mean (SD) values)*

Age (y)	*n*	*FEV$_1$**	*FVC**	*FEV$_1$*/FVC*%*
MEN				
60–64	17	1·68 (0·48)	2·72 (0·63)	61·76 (14·03)
65–69	42	1·77 (0·57)	2·77 (0·80)	63·90 (15·54)
70–74	54	1·80 (0·61)	2·69 (0·78)	66·90 (18·73)
75+	16	1·62 (0·56)	2·41 (0·73)	66·40 (18·90)
All men	129	1·75 (0·57)	2·69 (0·76)	65·06 (17·61)
WOMEN				
60–64	26	1·53 (0·31)	2·11 (0·52)	72·51 (12·28)
65–69	71	1·45 (0·42)	2·05 (0·52)	70·73 (14·91)
70–74	78	1·28 (0·36)	1·81 (0·45)	70·72 (13·00)
75+	35	1·38 (0·29)	1·98 (0·35)	69·70 (14·11)
All women	210	1·39 (0·37)	1·96 (0·48)	70·92 (14·16)

FEV$_1$*, FVC* = FEV$_1$ and FVC standardised to overall mean height.
Abbreviations as in table 1.

the predicted value = (age × c + k) × H^2, where c = regression coefficient, k = constant, H = height. For PEF height is used instead of height squared, as PEF was found to be proportional to height rather than height squared in a study of Chinese of all age groups.[4] The predicted values for 70 year old subjects of height 1·6 m (men) and 1·5 m (women) derived from our study are compared with those from other surveys of Chinese and white people in table 7.

Discussion

Throughout this study the same Compact spirometer was used. This instrument was chosen because it conformed with the requirements of the American Thoracic Society[11] and was portable.

There was no age related decline in FEV$_1$ or FVC among men, and only a slight decline among women. These findings are similar to those of Milne and Williamson,[1] but different from those of Burr *et al.*[2] Environmental factors such as smoking and air pollution[5] affect lung function, and differences in exposure to such factors may contribute to differences in spirometric values. For example, in contrast with the two existing studies on lung function in Chinese, only 15% of the men and 58% of the women were non-smokers in our sample, compared with 70% of the men and all the women in the Singapore study[9] and 54% and 90% in the study of Lam *et al*[4] in Hong Kong.

Table 4 *Regression equation for standardised lung function on age for men and women*

	Slope (SE)	*Constant*	*r*	*p*
MEN				
FEV$_1$* on age	0·002 (0·01)	1·63	0·04	NS
FVC* on age	−0·02 (0·01)	4·03	−0·15	NS
WOMEN				
FEV$_1$* on age	−0·013 (0·005)	2·30	−0·21	<0·05†
FVC* on age	−0·01 (0·006)	3·00	−0·21	<0·05†

FEV$_1$, FVC* = FEV$_1$ and FVC standardised to overall mean height.
†Statistically significant.
Abbreviations as in table 1.

Table 5 *Mean (SD) lung function in smokers and non-smokers (numbers of subjects in square brackets)*

	Mean standardised FEV$_1$	
	Men	*Women*
Current smokers	1·88 (0·52) [61]	1·30 (0·33) [41]
Ex-smokers	1·51 (0·62) [49]	1·32 (0·41) [47]
Non-smokers	1·98 (0·40) [19]	1·44 (0·37) [122]

For male current smokers *v* ex-smokers and ex-smokers *v* non-smokers $p < 0·01$ (Wilcoxon's rank sum test).

Although there is a clear age related decrease in FEV$_1$ and FVC in younger Chinese people,[4] it appears to reach a plateau after the age of 60 according to our study. The reasons for this are not clear, but possibly our sample consists of a substantial proportion of "survivors," those with poor lung function having died or no longer qualifying for sheltered housing, or having been excluded because of chronic bronchitis.

Selective survival of current smokers with better lung function and the exclusion of patients with chronic bronchitis may also explain our observation that the smokers' mean FEV$_1$ is no different from that of non-smokers and is higher than that of ex-smokers. Another possibility is that a proportion of ex-smokers gave up smoking because of greater lung damage. The observations on non-smokers, however, are based on relatively few subjects (15%) and therefore need to be interpreted with care. The fact that women smoke fewer cigarettes than men in Hong Kong[4] may explain why the three groups of women had similar FEV$_1$ values.

Table 6 *Constants and coefficients for regression equations*

	Constant (k)	*Regression coefficient (c) on age*	*SE of regression coefficient*	*SD*
MEN (n = 129)				
FEV$_1$/Ht^2	0·63	0·001	0·005	0·22
FVC/Ht^2	1·55	−0·007	0·006	0·29
PEF/Ht	102·98	1·105	1·42	67·61
WOMEN (n = 210)				
FEV$_1$/Ht^2	1·04	−0·006	0·003	0·17
FVC/Ht^2	1·35	−0·007	0·003	0·22
PEF/Ht	135·83	0·154	0·73	47·57

Example The predicted FEV$_1$ of a 70 year old man with a height of 1·6 m is calculated by applying the following equation:

$$\begin{aligned}FEV_1 &= (Age \times c + k) \times Ht^2\\ &= (70 \times 0{\cdot}001 + 0{\cdot}63) \times (1{\cdot}6)^2\\ &= 1{\cdot}79\end{aligned}$$

Abbreviations as in table 1.

Table 7 *Predicted values for 70 year old subjects, height 1·6 m (men) and 1·5 m (women), derived from various surveys*

	Men			Women		
	FEV_1 (l)	FVC (l)	PEF (l/min)	FEV_1 (l)	FVC (l)	PEF (l/min)
ELDERLY						
Milne[1] (Caucasian)	1·96	2·72	—	1·46	1·79	—
Burr[2] (Caucasian)	1·89	3·19	—	1·44	2·06	—
Present study (Hong Kong Chinese)	1·79	2·71	289	1·40	1·94	220
ALL AGES						
Ferris[13] (Caucasian)	2·22	2·86	—	1·59	1·94	—
Schmidt[12] (Caucasian)	2·37	3·26	—	1·87	2·49	—
Da Costa[6] (Singapore Chinese)	2·10	3·10	455	1·70	2·25	385
Lam[14] (Hong Kong Chinese)	1·80	2·55	340	1·55	2·05	270

Abbreviations as in table 1.

There was no evidence of continued adverse effects of smoking on FEV_1 in men without the symptoms of chronic bronchitis. In women a small decrease in FEV_1 with age was seen in ex-smokers, suggesting that the adverse effect of smoking on lung function in women persists in the older age groups (60–75+ years). The FEV_1/FVC ratio in women was similar to that in white women over 55 years old,[12] but the ratio for men was lower.

Our predicted values for elderly Chinese people are much lower than the widely quoted values from Da Costa's study of normal lung function in Chinese[6] (table 6). His study was mainly based on a much younger age group (mean age 37 years for men, 33 years for women), with only 26 subjects over 60 years old. Thus the regression equations he obtained are likely to be biased by the preponderance of younger subjects.

Our predicted values, except FEV_1 and FVC in men, are all slightly lower than those of the largest published study of lung function in Hong Kong Chinese, in which 332 subjects were aged over 65 years.[4] This may reflect selection bias as those subjects were all volunteers. It is debatable whether predicted values from the study of Lam *et al*[4] or from our study are more representative of elderly Chinese, as we are looking at a group who have remained fit by virtue of constitutional factors, including resistance to the effect of cigarette smoke. The numbers of subjects in the two studies were similar.

Our FEV_1 is slightly lower than the values found in studies of elderly white people, but the FVC is similar to that reported by Milne and Williamson.[1] The racial differences observed in surveys of younger subjects[4] would therefore appear to become less noticeable in the elderly.

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