Discordance Between Lung Function of Chinese University Students and 20-Year-Old Established Norms*

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Objective: **We examined the validity of the 20-year-old established Asian norms for pulmonary function in a contemporary cohort of Hong Kong Chinese university students.**

Design and participants: **Pulmonary function testing was conducted in university students (n = 805).**

Setting: **A university campus in Hong Kong.**

Measurements and results: **Parameters recorded included gender, age, height, weight, standard lung function variables (*ie*, FEV_1, FVC, and peak expiratory flow rate [PEFR]), and exhaled carbon monoxide (CO) level. Subjects completed a questionnaire on pulmonary health, smoking history, and their dietary and exercise habits within 3 months of the study. Data were compared with the established norms for lung function for Chinese persons from Hong Kong. On average, subjects were taller than those reported in the original cohort, on whom the established norms are based; however, FEV_1, FVC, and PEFR were lower. As predicted, the exhaled CO level was higher in smokers. Those who exercised regularly had a higher FEV_1 and FVC, and reported fewer respiratory complaints.**

Conclusions: **Our findings support the idea that lung function norms not only differ across ethnic groups, but that they may be susceptible to change over a single generation within an ethnic group living in the same geographic region. Assuming the equivalence of our testing methods and those on which established norms are based, our findings shed further insight into the dynamic nature of lung function, and have implications regarding the definition of normal pulmonary function and its variance over the short term.** ***(CHEST 2005; 128:1297–1303)***

Key words: Asian lung function norms; lifestyle factors; physical activity; university students

Abbreviations: BMI = body mass index; CO = carbon monoxide; PEFR = peak expiratory flow rate

Although ethnicity is an established determinant of lung function, predictive values for non-Western individuals in non-Asian countries are largely based on a proportion of established Western standards.[1,2] An Asian nomogram[3] based on 3,000 Hong Kong Chinese subjects who were 20 years of age, however, continues to be the reference standard used in Hong Kong. Since the time of that study, modifying factors of lung function have been reported or their effects have been better appreciated clinically. These effects include dietary factors,[4–6] obesity,[7,8] air pollution,[9] and physical activity.[10] With rapid economic growth and development over the last 20 years, the current generation of young adults in Hong Kong, has grown up with improved nutrition yet higher pollution.[11] The objective of this study was to validate the lung function norms that were established 20 years ago in a cohort of Hong Kong Chinese students who were born at the time that these norms were derived.

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Materials and Methods

Ethics approval was obtained from the ethics review committee of the Hong Kong Polytechnic University. Approval was also obtained from the student union of the university. Written informed consent was obtained from each subject prior to the data collection.

Subjects

An invitation to participate in a lung function assessment session was sent to all students at one of the universities in Hong Kong by mass electronic mailing. The assessment sessions were conducted at the university podium over a 2-week period. To limit interindividual differences due to age and time of year, the data collection was limited to young university students over a restricted time frame. To maximize the number of subjects recruited into the study, we compared pulmonary function testing performed in the field to that performed in the laboratory. This was also consistent with the procedures used by Lam and colleagues.[3]

Procedures

The study was explained and written consent was obtained from all subjects. Height and weight were then measured, and body mass index (BMI) calculated. Pulmonary function tests were conducted using two spirometers (Microlab 3300; Micro Medical Ltd; Kent, UK) and exhaled carbon monoxide (CO) level measured with a CO meter (Micro CO Meter; Micro Medical Ltd). Oxygen saturation was determined by a finger pulse oximeter (Onyx 9500; Nonin Medical, Inc; Plymouth, MN). Prior to the study, the CO meter was calibrated with a standard concentration of CO gas. The volume of each of 100 strokes of air from a 2-L super syringe to the two spirometers was recorded daily. The coefficients of variation of the volume measured by the two spirometers were $\leq$ 1%. The proper technique for performing lung function measurements was demonstrated to each subject, and the best result of three measurement trials was recorded.[2,12] The subjects completed a questionnaire that asked about smoking history, respiratory complaints and symptoms (*eg*, wheezing, shortness of breath on minimal exertion, cough, and sputum), nutritional status, and whether the subject participated in regular exercise over the past 3 months.

Statistical Analysis

A two-sample t test was used to compare the lung function parameters (*ie*, FEV_1, FVC, and peak expiratory flow rate [PEFR]) and height, measured in this study, with the mean values of the same parameters reported by Lam and colleagues.[3] For this comparison, the age of the subjects was stratified as reported in the study by Lam et al[3] (*ie*, 19 to 20, 21 to 22, and 23 to 24 years of age). Regression analysis was used to develop prediction equations for FEV_1, FVC, and PEFR from the data, and thereby to compare these pulmonary indexes derived from our data and those of Lam and colleagues.[3] The difference in lung function parameters between smokers and nonsmokers was tested by fitting two-way analysis of variance models, including the main effects of smoking and gender, and their interaction. If the interaction was not significant, then a simple main-effects analysis was adopted to determine the differences between smokers and nonsmokers. Subject characteristics, prevalence of respiratory symptoms, dietary habits, exercise habits, and differences between male and female subjects were compared with χ^2 tests, two-sample t tests, or Mann-Whitney tests, where appropriate. The association between respiratory symptoms and exercise habits was tested with χ^2 analysis. Lung function parameters were also compared among subjects with different exercise frequency, separately for each gender, with two-way analysis of variance models. The interaction between gender and exercise frequency was also examined. While the overall significance level was set at 0.05, the sharpened Bonferroni method[13] was used to adjust for individual α levels when multiple testing was performed.

Results

A total of 805 subjects participated in this study, of whom 518 were men and 287 were women. The smoking status of one male subject was unknown, thus he was excluded from the analysis. Only 5.7% of the subjects were smokers, and 2.2% were ex-smokers. Over one third of the subjects were living with family members who smoked. Subjects who smoked had a higher level of exhaled CO than nonsmokers ($p < 0.005$) [Table 1].

The BMIs of subjects were not reported in the study by Lam et al.[3] Our subjects, both men and women, were taller than those reported by Lam and colleagues.[3] There were, however, some distinctions between the genders. When we compared the men's data with those of Lam et al,[3] FEV_1, FVC, and PEFR were all lower in our cohort for subjects in each age category, specifically those who were 19 to 20, 21 to 22, and 23 to 24 years of age (Table 2). One exception was FVC for men who were 23 to 24 years old in cases in which there was no change. For the women, FEV_1, FVC, and PEFR were lower in our cohort, with the exception of FEV_1 for those in the group of subjects 23 to 24 years of age, and FVC for those in the groups of subjects 21 to 22 and 23 to 24 years of age (Table 2).

Table 1—*Pulmonary Indexes by Sex and Smoking Status**

	Male			Female		
Indexes	Smoker (n = 38)	Nonsmoker (n = 479)	p Value	Smoker (n = 8)	Nonsmoker (n = 279)	p Value
FVC, L	4.27 (0.73)	4.24 (0.64)	0.802	2.96 (0.69)	3.00 (0.48)	0.833
FEV_1, L	3.79 (0.59)	3.82 (0.48)	0.707	2.67 (0.54)	2.74 (0.40)	0.165
FEV_1/FVC, %	89.84 (6.65)	91.22 (6.48)	0.223	91.41 (6.64)	92.25 (7.06)	0.728
PEFR, L/s	8.06 (1.70)	8.19 (1.73)	0.632	4.92 (1.31)	5.15 (1.22)	0.686
CO, ppm	7.45 (4.96)	4.50 (2.35)	< 0.0005	10.13 (11.46)	3.93 (2.20)	< 0.0005
Spo_2, %	97.95 (0.70)	97.95 (0.89)	0.995	98.38 (0.92)	98.37 (0.71)	0.993

*Values given as mean (SD), unless otherwise indicated. Spo_2 = pulse oximetric saturation.