Spirometric Standards for Healthy Nonsmoking Adults[1]

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SUMMARY

Previous studies designed to establish normal standards for ventilatory testing have usually included substantial numbers of cigarette smokers and hospital patients. Forced expiratory flows and volumes were measured in 988 healthy nonsmoking men and women who had relatively little exposure to any form of air pollution. Xegative correlations were obtained with age and positive correlations with height. Prediction formulas were derived and nomograms were constructed for 4 standard ventilatory measurements. Comparisons were made with prediction formulas of other workers.

There was progressive decline in ventilatory function with age; larger values in men were present at all ages. Wide variation was encountered and was not attributable to age, sex, or height. This was most marked in the two forced expiratory flows, which had low multiple correlations and large standard errors of estimate.

The wide range of normal values seriously impairs the usefulness of spirometry in reliably detecting impairment of ventilatory function in asymptomatic individuals. Other techniques are needed to detect early impairment of pulmonary function.

Introduction

Spirometers are being used increasingly for measuring ventilatory function by individual physicians and in pulmonary function screening programs. The increased interest in spirometry is primarily related to the burgeoning incidence of chronic obstructive pulmonary disease. The widespread concern about air pollution and the well publicized harmful effects of inhaling cigarette smoke have also stimulated public interest in lung function testing.

Lagging behind the wider usage of spirometry has been the development of accurate normal standards. The value of spirometric testing is influenced to a large extent by the accuracy of predicted normal standards. Most recognized standards have included nonsmokers, smokers, and former smokers. Other factors such as previous .history of respiratory disease, degree of physical debility, and exposure to atmospheric pollution have not always been critically examined. The purpose of this study is to provide reliable normal ventilatory standards in the form of prediction equations and nomograms based upon a healthy nonsmoking population.

Materials and Methods

Most of the 988 subjects tested were members of the Church of Jesus Christ of the Latter Day Saints (55 per cent) and the Seventh Day Adventist Church (24 per cent). The tenets of both churches forbid tobacco smoking. The subjects

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TABLE 1

DISTRIBUTION OF SUBJECTS BY HALF DECADES

Age (years)	Number of Subjects: Women	Men
20-24	53	102
25-29	73	67
30-34	53	77
35-39	54	68
40-44	47	52
4549	42	42
50-54	44	41
56-59	27	26
60-64	25	16
65-69	16	11
70-74	19	9
75-79	10	2
80-84	8	4
Total	471	517

TABLE 2

MEAN VALUES AND STANDARD DEVIATIONS FOR PHYSICAL CHARACTERISTICS AND PULMONARY FUNCTION MEASUREMENTS

	Women		Men	
	Mean	SD	Mean	SD
Age, years	42.5	15.9	37.9	14.3
Height, inches	64.2	2.3	70.1	2.9
FVC, liter	3.47	0.74	5.2	0.97
FEV_1, liter	2.70	0.68	3.97	0.00
$FEF_{200-1200}$, liter/sec	5.2	1.4	7.9	1.8
$FEF_{25-75\%}$, liter/sec	3.1	1.0	4.1	1.3

lived in the mid-Willamette River Valley area of Oregon, south of Portland. This area is considered to be relatively free of significant urban air pollution, and the elevation is less than 500 feet above sea level.

The following procedures were used to obtain a population of nonsmokers who were free of disease or disability.

A questionnaire was filled out immediately before testing and established the following criteria regarding each subject: (1) never smoked cigarettes for a total period longer than six months; (2) never had asthma, chronic bronchitis, or pneumonia; (3) never had a persistent cough; (4) had not been treated recently for any respiratory condition; (5) never had persistent chest wheezing; (6) never had any chest injury or operation; (7) never worked in a polluted atmosphere for any extended period.

An interview cross-checked the results of the questionnaire to eliminate subjects not fulfilling the criteria.

During the testing, the subjects were observed for coughing or wheezing. The subjects' height was measured without shoes. All tests were done in the standing position, and a nose-clip was used. The tests were performed at various times of the day, but most were done between 7 pm and 9 pm. Two Stead-Wells spirometers with the soda lime cannister and two flutter valves removed from each were used. All tests were conducted by 6 trained technicians. The ventilatory tests consisted of the forced vital capacity (FVC), forced expiratory volume at 1 second (FEV_1), forced expiratory flow ($FEF_{200-1200}$), and forced midexpiratory flow ($FEF_{25-75\%}$). The terminology of the ventilatory function tests is in accordance with the recommendations of the Committee on Pulmonary Physiology of the

TABLE 3

CORRELATION COEFFICIENTS OF PHYSICAL CHARACTERISTICS AND PULMONARY FUNCTION MEASUREMENTS FOR WOMEN

	Age (years)	Height (inches)	FVC (liter)	FEV_1 (liter)	$FEF_{200-1200}$ (liter/sec)	$FEF_{25-75\%}$ (liter/sec)
Age, years	1.0	−0.61	−0.47	−0.54	−0.66	−0.25
Height, inches	−0.61	1.0	0.61	0.48	0.82	0.50
FVC. liter	−0.47	0.61	1.0	0.61	0.65	0.35
FEV_1, liter	−0.54	0.40	0.61	1.0	0.71	0.27
$FEF_{200-1200}$, liter/sec	−0.66	0.82	0.65	0.71	1.0	0.45
$FEF_{25-75\%}$, liter/sec	−0.25	0.50	0.35	0.27	0.45	1.0

M = 471

TABLE 4

CORRELATION COEFFICIENTS OF PHYSICAL CHARACTERISTICS AND PULMONARY FUNCTION MEASUREMENTS FOR MEN

	Age (years)	Height (inches)	FVC (liter)	FEV_1 (liter)	$FEF_{200-1200}$ (liter/sec)	$FEF_{25-75\%}$ (liter/sec)
Age, years	1.0	−0.49	−0.41	−0.52	−0.65	−0.26
Height. inches	−0.49	1.0	0.39	0.36	0.77	0.54
FVC, liter	−0.41	0.39	1.0	0.44	0.51	0.27
FEV_1, liter	−0.52	0.36	0.44	1.0	0.73	0.23
$FEF_{200-1200}$, liter/sec	−0.65	0.77	0.51	0.73	1.0	0.48
$FEF_{25-75\%}$, liter/sec	−0.26	0.54	0.27	3.23	0.48	1.0

M = 517

American College of Chest Physicians (1). Each test was performed at least twice to obtain a maximal effort. The best effort was always selected. Lung volumes were corrected to body temperature and pressure, saturated with water vapor (BTPS). The methods of calculation were those of Kory and associates (2). The results were randomly checked for accuracy by an independent pulmonary function laboratory.

Results

A total of 988 healthy nonsmoking men and women were included in the study. The distribution by half decades of age from 20 to more than 80 years is shown in table 1. The means and standard deviations for age and height for each sex are listed in table 2. Weight and body surface area as physical characteristics was not included. Kory and associates (2) reported that weight had little or no correlation with any of the spirometric measurements.

The matrix for product-moment correlation (*r*) based on the two physical characteristics and four ventilatory function measurements are shown in tables 3 and 4. Negative correlations were obtained between each lung function measurement and age. The $FEF_{200-1200}$ showed the largest negative correlation with age for both sexes. Height was directly related to all four lung functions. The $FEF_{200-1200}$ had the largest positive correlation coefficient with height. Because all four pulmonary functions showed correlation with age and height, prediction formulas were derived for all spirometric variables for both sexes. The prediction formulas are listed in table 5.

To facilitate determination of the predicted values, a nomogram for each sex was constructed which included the four ventilatory functions and the two physical measurements (figures 1 and 2). By using a

TABLE 5

PREDICTION FORMULAS WITH MULTIPLE CORRELATION COEFFICIENT (R) AND STANDARD ERROR OF ESTIMATE (SEE)

Prediction Formula	R	SEE
Women		
$FVC = 0.115\,H_{in} - 0.024A - 2.852$	0.71	0.52
$FEV_1 = 0.089\,H_{in} - 0.025A - 1.932$	0.73	0.47
$FEF_{200-1200} = 0.145\,H_{in} - 0.036A - 2.532$	0.53	1.19
$FEF_{25-75\%} = 0.060\,H_{in} - 0.030A + 0.551$	0.56	0.80
Men		
$FVC = 0.148\,H_{in} - 0.025A - 4.241$	0.65	0.74
$FEV_1 = 0.092\,H_{in} - 0.032A - 1.260$	0.73	0.55
$FEF_{200-1200} = 0.109\,H_{in} - 0.047A + 2.010$	0.44	1.66
$FEF_{25-75\%} = 0.047\,H_{in} - 0.045A + 2.613$	0.63	1.12

Key: H_{in} = height in inches; A = age in years.

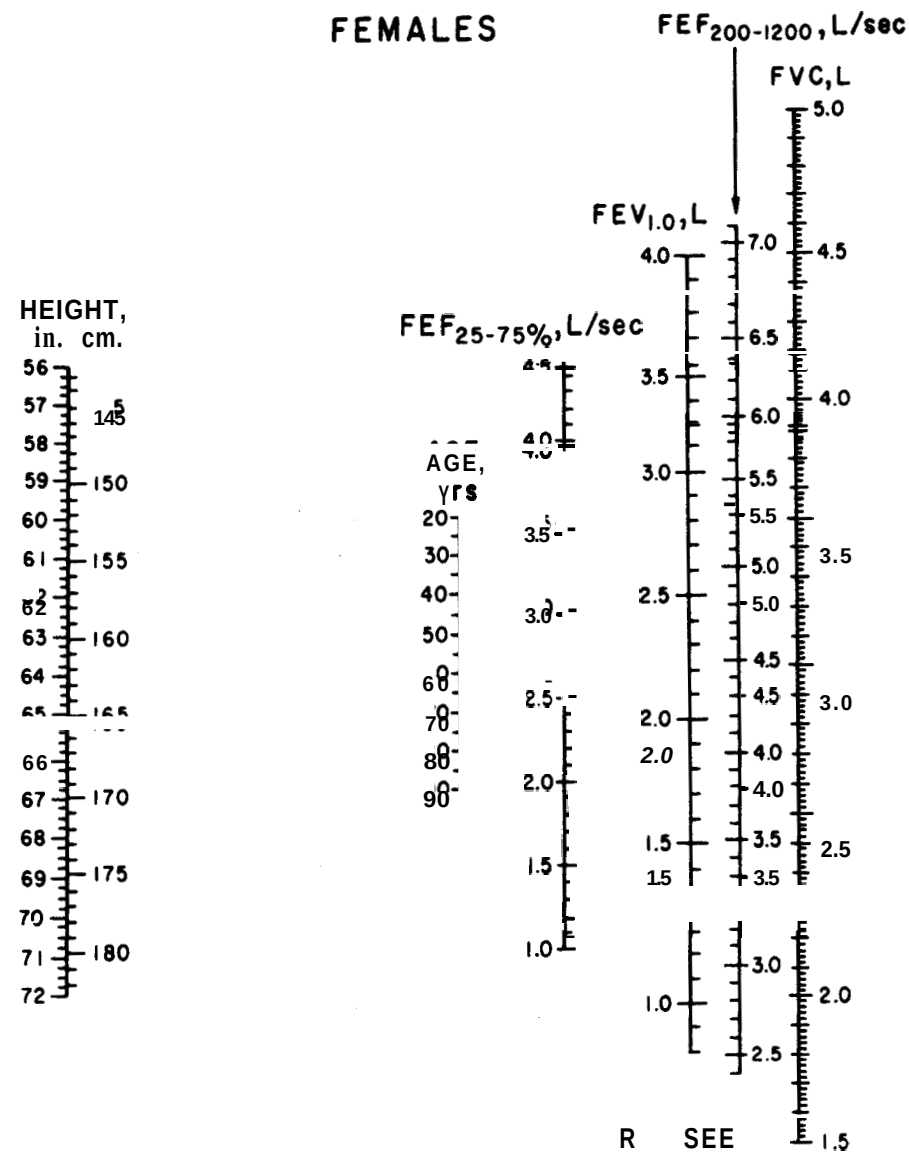

Fig. 1. Prediction nomogram for normal women.

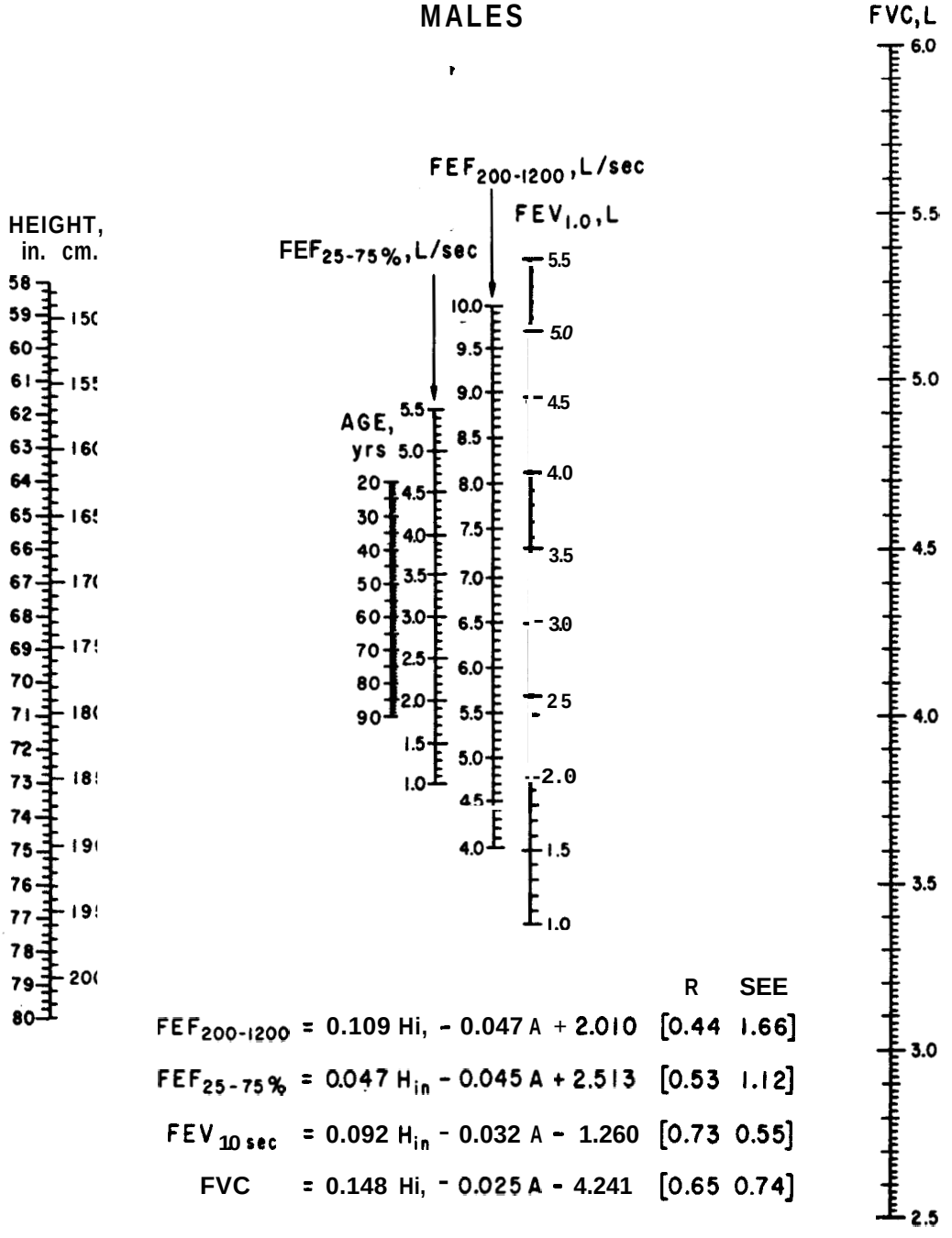

Fig. 2. Prediction nomogram for normal men.

TABLE 6

COMPARISON OF PREDICTION FORMULAS FOR WOMEN USING MEAN VALUES FOR AGE AND HEIGHT FROM PRESENT STUDY

Investigators	Test (liter)	Prediction Formula	SEE	Pred Mean	Obs Mean	Differe
Morris et al	FVC	$0.115\ H_{in} - 0.024A - 2.852$	0.52	3.51	3.47	+0.04
Berglund et al (15)	VC	$0.040\ H_{cm} - 0.022A - 2.351$	0.40	3.24	3.47	−0.23
Ferris et al (17)*	FVC	$0.033\ H_{cm} - 0.023A - 1.40$	0.46	3.00	3.47	−0.47
Ferris et al (17)†	FVC	$0.030\ H_{cm} - 0.023A - 0.94$	0.47	2.98	3.47	−0.49
Goldman et al (18)	VC	$0.052\ H_{cm} - 0.018A - 4.36$	0.43	3.36	3.47	−0.11
Kory et al (20)	FVC	$0.041\ H_{cm} - 0.018A - 2.69$	0.37	3.23	3.47	−0.24
Needham et al (19)	VC	$0.039\ H_{cm} - 0.020A - 2.71$	0.36	2.87	3.47	−0.60
Morris et al	FEV_1	$0.089\ H_{in} - 0.025A - 1.932$	0.47	2.72	2.70	+0.02
Berglund et al (15)	FEV_1	$0.0267\ H_{cm} - 0.027A - 0.54$	0.36	2.67	2.70	−0.03
Ferriset al (17)*	FEV_1	$0.025\ H_{cm} - 0.022A - 0.62$	0.40	2.52	2.70	−0.18
Ferris et al (17)†	FEV_1	$0.022\ H_{cm} - 0.024A - 0.08$	0.42	2.49	2.70	−0.21
Kory et al (20)	FEV_1	$0.028\ H_{cm} - 0.021A - 0.87$	0.33	2.80	2.70	+0.10
Lindall et al (10)	FEV_1	$67.6\ H_{in} - 23.0A - 918$	0.36	2.44	2.70	−0.26

Key: H_{in} = height in inches; H_{cm} = height in centimeters; A = age in years.
* Included smokers.
† Included nonsmokers and exsmokers

straight edge to connect an individual's age and height, all four values of forced expiration can be obtained at once.

Comparisons between the present study and previous studies regarding prediction formulas are shown in tables 6 and 7, 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 formulas of previous studies in calculating the predicted mean. The observed means are those that were calculated from the total sample of the present study. The difference between predicted and observed means permitted comparison of the different piediction formulas. Of the 24 predicted means shown in tables 6 and 7, only the FEV, of women re-

TABLE 7

COMPARISON OF PREDICTION FORMULAS FOR MEN USING MEAN VALUES FOR AGE AND HEIGHT FROM PRESENT STUDY

Investigators	Test (liter)	Prediction Formula	SEE	Pred Mean	Obs Mean	Difference
Morris et al	FVC	$0.148\ H_{in} - 0.025A - 4.241$	0.74	5.19	5.20	−0.01
Berglund et al (15)	VC	$0.048\ H_{cm} - 0.020A - 2.81$	0.50	4.98	5 20	−0.22
Cotes (16)	FVC	$0.051\ H_{cm} - 0.032A - 3.02$	0.52	4.84	5.20	−0.36
Ferris et al (17)*	FVC	$0.051\ H_{cm} - 0.025A - 3.55$	0.59	4.59	5.20	−0.61
Ferris et al (18)†	FVC	$0.046\ H_{cm} - 0\ 027A - 2.79$	0.66	4.38	5.20	−0.82
Goldman et al (19)	VC	$0.064\ H_{cm} - 0.031A - 5.335$	0.49	4.89	5.20	−0.31
Kory et al (2)	VC	$0.052\ H_{cm} - 0.022A - 3.60$	0.58	4.83	5.20	−0.37
Needham et al (19)	VC	$0.043\ H_{cm} - 0.035A - 1.91$	0.44	4.42	5.20	−0.78
Morris et al	FEV_1	$0.092\ H_{in} - 0.032A - 1.260$	0.55	3.98	3.97	+0.01
Anderson (20)	FEV_1	$0.005\ H_{cm} - 0.029A + 3.614$	0.61	3.41	3.97	−0.56
Berglund et al (15)	FEV_1	$0.034\ H_{cm} - 0.033A - 1.00$	0.50	3.80	3.97	−0.17
Cotes (16)	FEV_1	$0.035\ H_{cm} - 0.033A - 1.12$	0.45	3.79	3.97	−0.18
Ferris et al (17)*	FEV_1	$0.036\ H_{cm} - 0.027A - 1.65$	0.49	3.79	3.97	−0.23
Ferris et al (17)†	FEV_1	$0.029\ H_{cm} - 0.028A - 0.70$	0.59	3.40	3.97	−0.03
Kory et al (2)	FEV_1	$0.037\ H_{cm} - 0.028A - 1.59$	0.52	3.94	3.97	

Key: H_{in} = height in inches; H_{cm} = height in centimeters; A = age in years.
*Included smokers.
† Included nonsmokers and exsmokers.

ported by Kory and associates exceeded the value in the present study.

The decline in lung function by age for each sex is illustrated in figures 3 and 4. This presumably represented the effects of aging rather than smoking or apparent, pulmonary disease because of the criteria for selection of subjects. The mean values of all four tests demonstrated larger values for men at all ages.

Discussion

As recently as 1969, Leiner and associates (3) stated: "there is need for standardization of methods, prediction formulas, and normal ranges for various pulmonary function tests." This comment resulted from a questionnaire survey of pulmonary residency programs concerning pulmonary function testing. The most frequently used normal standards for ventilatory testing are those compiled by the Veterans Administration–Army Cooperative Study (2). No data regarding the smoking habits of the subjects, however, were provided. In the second paper of the same study (4), 337 men performed forced expiratory volumes and flows. Histories of cigarette smoking were obtained from 193 of the men. Of these, 76 per cent were listed as cigarette smokers. Most of the participating hospitals in the Veterans Administration–Army study were in large urban centers. The second most frequently

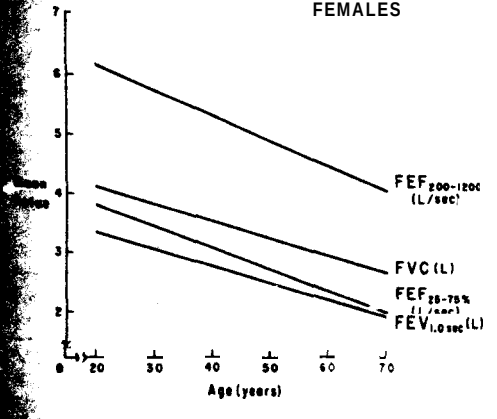

Fig. 3. Relationship of forced expiratory measurements to age in normal women.

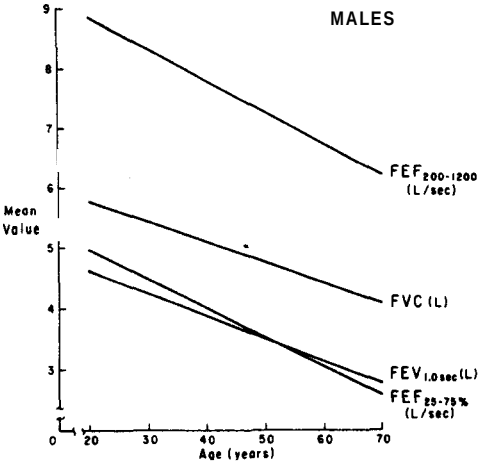

Fig. 4. Relationship of forced expiratory measurements to age in normal men.

used standards are those of Baldwin and coworkers (5), which include values for the supine vital capaaty but not the FEV,.

The questionnaire survey also revealed that the $FEF_{25-75\%}$ was frequently used by the 73 responding laboratories from which usable information was obtained. Twenty-six of these laboratories reported using the Veterans Administration–Army prediction equations, although the reference cited provided no prediction equations (2). Twelve of the responding laboratories used equations provided by Leuallen and Fowler (6), but there was wide variation among the laboratories in selecting the lower limit of normal. The $FEF_{200-1200}$ was used least often of the standard spirometric tests, and the Veterans Administration–Army prediction equations were again reported to be most commonly used although none was given in the reference ated (2).

The present study found regression with age and decreasing height for all four tests of forced expiration. Correlation coefficients for the four tests showed considerable variation, ranging from 0.25 to 0.82. The value of forced expiratory flows, especially the $FEF_{25-75\%}$, has been both praised and condemned. The test has been recommended by some as an early index of airway obstruction (6) whereas others (7, 8) have found

TABLE 8

LUNG V LUME MEASUREMENTS BY AGE DECADES FOR WOMEN
MEAN VALUES AND STANDARD DEVIATIONS

	20-29	30-39	40-49	50-59	60-6	70-79	80-UP
Age, years	25.02 (2.84)*	34	44.60 (2.66)	53.54 (2.58)	64.17 (2	74.00 (2.92)	82.75 (2.92)
Height, inches	64.74 (2.26)	64	64.22 (2.38)	63.59 (2.22)	63.41 (2	62.65 (2.05)	64.00 (1.79)
FVC, liter		3	3.47 (.55)	3.10 (.52)	2.86 (	2.50 (.79)	2.24 (.47)
FEV_1, liter	3.15 (.53)	3	2.64 (.43)	2.35 (.45)	2.15 (	1.71 (.32)	1.63 (.32)
$FEF_{200-1200}$, liter/sec	5.74 (1.05)	5	5.24 (1.03)	4.99 (1.69)	4.42 (1	3.40 (1.28)	3.12 (.69)
$FEF_{25-75\%}$, liter/sec	3.76 (.87)	3	3.02 (.75)	2.86 (.97)	2.60 (	1.89 (.52)	2.03 (.64)
Number of subjects	126	107	89	71	41	29	8

*Figures in parentheses represent SD

TABLE 9

LUNG V LUME MEASUREMENTS BY AGE DECADES FOR MEN
MEAN VALUES AND STANDARD DEVIATIONS

	20-29	30-39	40-49	50-59	60-69	70-79	80-UP
Age, years	23.53 (3.03)*	4.3	44.15 (2.64)	53.82 (2.66)	64.00 (2.	72.82 (2.75)	91.50 (6.95)
Height, inches	70.78 (2.85)	0.1	69.89 (2.70)	69.86 (2.76)	68.29 (2.	66.82 (3.23)	65.88 (4.01)
FVC, liter	5.57 (.94)	5.3	5.05 (.67)	4.88 (.81)	4.20 (	3.38 (.44)	2.97 (.85)
FEV_1, liter	4.49 (.67)	4.0	3.79 (.54)	3.50 (.59)	2.97 (	2.49 (.39)	1.72 (.36)
$FEF_{200-1200}$, liter/sec	8.56 (1.70)	3.1	7.71 (1.63)	7.39 (1.85)	6.63 (1.	5.50 (.70)	3.29 (1.32)
$FEF_{25-75\%}$, liter/sec	4.87 (1.23)	.1	3.77 (.95)	3.45 (1.16)	2.97 (1.	2.82 (.90)	1.18 (.38)
Number of subjects	169	145	94	67	27	11	4

*Figures in parentheses represent SD

less useful than other measurements because of poor correlation with other ventilatory measurements or the wide range of normal values. Previous reports providing normal values for $FEF_{200-1200}$ and $FEF_{25-75\%}$ have not included prediction formulas because correlations with age and height were of insufficient magnitude (2, 4). Tables have been provided for forced expiratory flows by age groups (7, 9). Birath and associates (8) and Lindall and associates (10) developed prediction formulas for $FEF_{25-75\%}$ using age alone. The results of the present study of a nonsmoking population reflect correlations of higher magnitude than reported in previous studies. The $FEF_{200-1200}$ had negative correlations with age of $r = -0.66$ for women and of $r = -0.65$ for men. There were positive correlations with height of $r = +0.82$ for women and $r = +0.77$ for men. The $FEF_{25-75\%}$ had low negative correlations with age of $r = -0.25$ for women and $r = -0.26$ for men. Correlations with height were $r = +0.50$ for women and $r = +0.54$ for men. It should be noted that the regression equations using age and height for prediction of the two forced expiratory flows for men and women have low multiple correlations (R), and large standard errors of estimate (SEE). The prediction formulas for the two tests should be used with awareness of these limitations.

Correlation of the present data with other published reports is handicapped by differences in testing equipment and procedures. The Stead-Wells spirometer was chosen for the present study because of its wide usage in major pulmonary function laboratories (3) and its reported superiority to the also widely used Collins 13.5-liter spirometer, particularly for forced expiratory flows (11). A major problem in the applicability of prediction equations is the variety of testing apparatuses. The variation among types of spirometers should be determined to demonstrate the usefulness of certain normal standards or the need for their modification. Tests that depend upon the uniqueness of a given apparatus such as peak flow meters require their own instrumental standards and make comparison between instruments impractical.

The decline of ventilatory function with age presumably represents species-specific, genetically determined, biological decay. Deterioration of pulmonary function appears to be fairly constant with advancing age, even in the absence of impairment by respiratory disease, cigarette smoking, or atmospheric pollution. Most survey studies, even those directed toward the elderly (12), do not include an adequate portion of the aged population. Larger numbers of normal subjects over the age of 70 should be studied to achieve statistically valid prediction equations for the aged.

Resistance to airflow is caused mainly by two mechanisms, namely, intrinsic airway narrowing, and airway collapse. Airway closure has been shown to occur at higher lung volumes with advancing age (13). The normal population in this study can be considered to be free of bronchitis and other intrinsic airway diseases, but subject to the changes of aging.

It is likely that the present study provides the most reliable standards available for predicting normal forced expiration measurements in the adult man and woman. This results from selection of a healthy non-

TABLE 10

COEFFICIENT OF VARIATION FOR LUNG VOLUME MEASUREMENTS

Age (years)	20-29		30-39		40-49		50-59		60-69	
Sex	F	M	F	M	F	M	F	M	F	M
FVC	12	17	18	18	16	13	17	17	18	16
$FEV_{1.0}$	17	15	20	15	16	14	19	17	29	22
$FEF_{200-1200}$	18	20	22	21	20	21	34	25	27	25
$FEF_{25-75\%}$	23	25	23	28	25	25	34	34	32	45

* Numbers represent the SD divided by mean value for each decade, expressed as per cent.

smoking population covering a wide age range of both sexes. Despite this selection, the values demonstrate a steady decline in pulmonary function with age, and a wide variation from mean values not attributable to age, height, or sex. The regression equations reflect the total sample whereas tables 8 and 9-show the extent of variaiton from the normal mean by age groups of ten years. The coefficient of variation for each decade up to age 70 is shown in table 10. By definition, the mean ± one SD includes 68 per cent of the population tested, excluding 32 per cent of the normal individuals falling outside of one SD of the mean.

Sobol has emphasized the difficulties in detecting abnormal pulmonary function in the asymptomatic individual by simple ventilatory tests (14). To achieve the desirable goal of reliable early detection of chronic obstructive pulmonary disease, development of testing techniques other than spirometry will be required. For the present, spirometry will continue to be of value in documentation of the degree of ventilatory insufficiency in the symptomatic patient, and for serial observations of progression of disease or the beneficial effects of therapy.

Acknowledgment

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RESUMEN

Valores espirométricos en adultos no fumadores saludables

Prcvios estudios practicados para determinar los valores normales de las pruebas ventilatorias, han incluido gencralmente un numero considerable de fumadores de cigarrillos y de pacientes hospitalizados. Se detcrminaron los valores de la velocidad y del volumen del flujo espiratorio forzado en 988 hombres y mujeres saludables, no fumadores, quienes habian sufrido relativamente poca exposición a un ambiente contaminado. Se observó una correlación negativa con la edad y positiva con la estatura. Se derivaron fórmulas pronosticadoras y se construyeron nomogramas para cuatro valores ventilatorios normales. Se compararon las fórmulas pronosticadoras con las de otros investigadores.

Se observó una disminución progresiva en la función ventilatoria con la edad; en todas las edades, superaron los varones. Ocurrieron amplias variaciones en todo el grupo, no atribuibles a la edad. sexo o estatura. Esto fue más pronunciado en las dos velocidades espiratorias forzadas, con correlaciones múltiples bajas y con grandes errores en lo estimado.

Las amplias variaciones de los valores normales afectan seriamente la utilidad de la espirometria en descubrir con certeza el deterioro de la función ventilatoria en sujetos asintomáticos. Se hace necesario emplear diversas técnicas para descubrir precozmente la función pulmonar impedida.

RESUME

Standards spirométriques pour les adultes non-fumeurs et en bonne santé

Les etudes qui ont été précédemment menées en vue d'établir des valeurs normales d'ktalonnage pour les épreuves ventilatoires, ont habituellement inclus un nombre important de fumeurs de cigarettes et de malades hospitalisés. Les taux de débit expiratoire forcé et les volumes ont été mesurés chez 988 hommes et femmes, en bonne santé et non fumeurs, qui avaient eu une exposition relativement faible à la pollution de l'air, sous quelque forme que ce soit. On a obtenu des corrélations négatives avec l'âge, et des corrélations positives avec la taille. On en a dérivé des formules de prediction, et des nomogrammes ont été construits pour quatre mesures étalons de la ventilation. Des comparaisons ont été effectukes avec les formules de prediction établies par d'autres chercheurs.

On a observe une diminution progressive de la fonction ventilatoire avec l'âge. La supériorité des hommes à cet égard est cependant maintenue à tous les âges. De larges variations ont été observées dans la population, qui ne pouvaient pas Ctre attribuées à l'âge, au sexe ou à la taille. Ces variations Ctaient les plus prononcées pour les deux taux de débit expiratoire forcé, qui témoignaient de correlations multiples faibles,

que d'erreurs standard élevées pour les nations qui en étaient faites.

existence d'une gamme importante de valeurs males constitue un obstacle sérieux à l'utilisa- de la spirométrie, lorsqu'il s'agit de dépister ne manière fiable une détérioration de la ction ventilatoire chez les individus ne pré- tant pas de symptômes, Il est nécessaire d'avoir cours à des techniques différentes pour détecter e déterioration précoce de la fonction pul- onaire.

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