Spirometric values for normal adult males in Greece

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We have measured the vital capacity and forced expiratory volume in 1 second of 50 healthy men aged 20 to 25 and 50 aged 55 to 60 years in order to obtain normal values for reference use for pulmonary tests in Greece. We constructed tables of mean and 95% confidence limits for ages 20 to 70 and height 1.5 to 1.9 metres, assuming that these respiratory values vary linearly with age and height. The differences in our results from those obtained in the United States of America and in France show that misinterpretation of pulmonary function tests may result from inappropriate reference values.

For several years the normal values for vital capacity (VC) and forced expiratory volume in one second (FEV₁) used as reference standards in Greece were those of Baldwin, Courmand, and Richards (1948). Data obtained more recently in men of European descent from the U.S.A. (Kory, Callahan, Boren, and Syner, 1961), Britain (Cotes, Higgins, Rossiter, and Wilton, 1964; Cotes, 1965), and Sweden (Berglund *et al.*, 1963) are similar. Those obtained from France, however (Commission des Communautés Européennes, 1967), show considerable differences. We therefore considered it necessary to establish normal reference values for Greece, where different genetic and environmental conditions prevail from those in Western Europe and the U.S.A., and the present work was undertaken for that purpose.

MATERIAL AND METHODS

We studied a group of 50 men aged 20 to 25 years and another group of 50 aged 55 to 60 years. Most of the subjects in the younger age group were medical students. The older group included various professions, the white-collar employee being predominant. All subjects were selected on two criteria: (a) absence of pulmonary symptoms (cough, sputum, and dyspnoea) and (b) absence, within the previous three years, of a chest illness causing time off work. None of the subjects gave a history of cough and sputum on most days for as much as three months in the year. The smoking habits of the subjects were not taken into consideration because in previous studies (Cotes *et al.*, 1964) it was established that subdivision of the subjects according to their tobacco consumption revealed no significant differences in FEV₁.

We measured the VC and the FEV₁ with a MacDermott dry spirometer designed and manufactured at the Pneumoconiosis Research Unit of the Medical Research Council. The apparatus is self-correcting for B.T.P.S. The overall calibration of the apparatus was tested frequently by the method described by McKerrow, McDermott, and Gilson (1960) and was found to be unaltered throughout the studies. Each subject was asked to perform four consecutive tests and the result of the highest was recorded. In almost all the subjects no differences were noted between the efforts. The standing height in bare feet was measured.

Regressions were calculated between standing height and respiratory values in each age group separately. The mean values of VC and FEV₁ as well as the corresponding lower level of the 95% confidence limits—as applied to individual values—were calculated for each height, in steps of 5 cm, from 1.5 m to 1.9 m as the decrease in respiratory values with age is known to be closely linear (Cotes, 1965). The expected values for other ages, intermediate to the above age groups, were calculated by linear interpolation, which was applied on both the mean and the lower confidence interval limit. The body-weight of the subjects was not taken into consideration (Kory *et al.*, 1961).

RESULTS

The mean heights of the two age groups (Table I) differ significantly ($P < 0.01$) but their variances are almost identical. The variances of VC and FEV₁ do not differ significantly between the two groups. There is a statistically significant difference as far as the VC-height correlation coefficient is concerned ($P < 0.05$), in contrast to the FEV₁,

TABLE I
SPIROMETRIC VALUES AND STATISTICAL FEATURES OF
TWO AGE GROUPS

	Age Group	
	20-25 n=50	55-60 n=50
Height (metres)	1.74 0.062	1.64 0.005
Vital capacity (litres)	5.43 0.588	3.92 0.595
Coefficient of variation	11%	15%
FEV ₁ (litres)	4.77 0.511	2.95 0.482
Coefficient of variation	11%	16%
Correlation coefficient		
VC-Height	0.77	0.52
FEV ₁ -Height	0.73	0.61
Regression equation		
VC-Height	7.326H _m -7.34	5.601H _m -5.27
Seb	0.375	0.411
FEV ₁ -Height	6.025H _m -5.73	5.364H _m -5.87
Seb	0.349	0.386

height correlation coefficient in which no such difference exists. The regression coefficients do not differ between the two groups and the regression equations are similar. In the 20 to 25 year age group the regression of VC on height was $7.326H_m - 7.34$, that of the 55 to 60 year age group being $5.601H_m - 5.27$. The regression of FEV₁ on height was respectively $6.025H_m - 5.73$ and $5.364H_m - 5.87$.

Table II presents the expected values which can be considered as normal in Greece as well as their lower 95% confidence limits. Thus an individual with spirometric values lower than these limits has a 2.5% probability of being normal.

TABLE II

NORMAL REFERENCE VALUES (LITRES) VC AND FEV₁ IN GREECE IN RELATION TO AGE AND HEIGHT

(a) Vital Capacity

Height (m)	Age Group									
	20-25	26-30	31-35	36-40	41-45	46-50	51-55	56-60	61-65	66-70
1.50	3.65 2.78	3.58 2.71	3.50 2.63	3.43 2.56	3.35 2.48	3.28 2.41	3.20 2.32	3.13 2.24	3.05 2.17	2.98 2.09
1.55	4.02 3.19	3.94 3.11	3.58 3.02	3.77 2.94	3.68 2.85	3.59 2.76	3.50 2.67	3.41 2.58	3.33 2.50	3.24 2.41
1.60	4.38 3.58	4.28 3.47	4.18 3.37	4.08 3.27	3.98 3.17	3.88 3.06	3.78 2.96	3.69 2.86	3.59 2.76	3.50 2.66
1.65	4.74 3.98	4.63 3.86	4.52 3.74	4.41 3.62	4.30 3.50	4.19 3.38	4.08 3.26	3.97 3.14	3.86 3.02	3.75 2.90
1.70	5.11 4.35	4.99 4.22	4.86 4.08	4.74 3.95	4.61 3.82	4.49 3.68	4.38 3.55	4.25 3.42	4.13 3.29	4.00 3.15
1.75	5.48 4.72	5.35 4.57	5.21 4.42	5.08 4.27	4.94 4.12	4.80 3.97	4.67 3.82	4.53 3.66	4.40 3.51	4.26 3.36
1.80	5.84 5.08	5.69 4.91	5.54 4.74	5.39 4.57	5.25 4.40	5.10 4.23	4.96 4.06	4.81 3.90	4.67 3.73	4.53 3.56
1.85	6.21 5.42	6.05 5.23	5.89 5.05	5.73 4.87	5.57 4.68	5.41 4.50	5.25 4.32	5.09 4.13	4.93 3.95	4.77 3.76
1.90	6.58 5.77	6.40 5.57	6.23 5.37	6.08 5.17	5.90 4.97	5.72 4.77	5.54 4.57	5.37 4.36	5.20 4.16	5.02 3.96

(b) Forced Expiratory Volume (FEV₁)

Height (m)	Age Group									
	20-25	26-30	31-35	36-40	41-45	46-50	51-55	56-60	61-65	66-70
1.50	3.31 2.50	3.15 2.34	2.99 2.17	2.83 2.00	2.67 1.84	2.51 1.67	2.35 1.50	2.18 1.34	2.02 1.18	1.86 1.01
1.55	3.61 2.83	3.44 2.66	3.28 2.49	3.11 2.32	2.94 2.15	2.78 1.99	2.61 1.82	2.44 1.66	2.28 1.50	2.11 1.33
1.60	3.91 3.16	3.74 2.98	3.57 2.80	3.40 2.63	3.23 2.46	3.06 2.28	2.89 2.01	2.71 1.93	2.54 1.76	2.37 1.58
1.65	4.21 3.50	4.04 3.31	3.86 3.12	3.68 2.94	3.50 2.75	3.33 2.57	3.15 2.38	2.98 2.20	2.81 2.02	2.63 1.84
1.70	4.51 3.80	4.33 3.61	4.15 3.42	3.97 3.23	3.79 3.04	3.61 2.85	3.43 2.66	3.25 2.47	3.07 2.28	2.89 2.09
1.75	4.81 4.10	4.63 3.90	4.44 3.70	4.26 3.50	4.07 3.30	3.89 3.10	3.70 2.90	3.52 2.70	3.34 2.50	3.15 2.30
1.80	5.12 4.41	4.93 4.20	4.74 3.99	4.55 3.78	4.36 3.57	4.17 3.36	3.98 3.15	3.79 2.94	3.60 2.73	3.41 2.52
1.85	5.42 4.69	5.23 4.46	5.03 4.22	4.84 3.99	4.64 3.75	4.45 3.52	4.25 3.28	4.05 3.05	3.86 2.82	3.66 2.58
1.90	5.72 4.96	5.52 4.73	5.32 4.50	5.12 4.27	4.92 4.05	4.72 3.82	4.52 3.59	4.32 3.37	4.12 3.15	3.92 2.92

Upper row: mean values; lower row: lower values—95% confidence limit.

DISCUSSION

The Figure compares our results with those of the French and American studies. It can be seen firstly that as far as VC is concerned, the North American values are lower than both the Greek and, especially, the western European ones. In addition, their confidence interval being, in general, wider, the lower normal limits differ, in

some cases, by almost one litre from the corresponding west European ones. This is not surprising as it is well known that the latter suffer from an upward bias, but these values are used extensively in Europe and their comparison with other values may always be fruitful. Secondly, the Greek mean values of FEV_1 are higher than those of the U.S. for younger ages (20 or 30 years) but the differences decrease progressively with age.

FIGURE. The relation of (a) vital capacity and (b) forced expiratory volume in 1 second (FEV_1) to age for three different heights (160, 170, and 180 cm). Data for subjects from the U.S.A. (---), France (---), and Greece (—).

VITAL CAPACITY: MEAN VALUES AND 95% CONFIDENCE LIMIT

Height (m)		Age Group				
		20–	30–	40–	50–	60–
1.60	Greece	4.43 (3.63)	4.23 (3.42)	4.03 (3.22)	3.83 (3.01)	3.63 (2.81)
	U.S.A.	4.28 (3.12)	4.06 (2.90)	3.84 (2.68)	3.62 (2.46)	3.40 (2.24)
	Central Europe	4.20 (3.49)	4.18 (3.47)	4.10 (3.40)	3.97 (3.30)	3.81 (3.16)
1.70	Greece	5.17 (4.41)	4.93 (4.16)	4.68 (3.89)	4.43 (3.62)	4.19 (3.36)
	U.S.A.	4.80 (3.64)	4.58 (3.42)	4.36 (3.20)	4.14 (2.98)	3.92 (2.76)
	Central Europe	5.04 (4.18)	5.01 (4.16)	4.91 (4.08)	4.77 (3.96)	4.57 (3.79)
1.80	Greece	5.91 (5.15)	5.62 (4.84)	5.32 (4.50)	5.03 (4.16)	4.74 (3.83)
	U.S.A.	5.32 (4.16)	5.10 (3.94)	4.88 (3.72)	4.66 (3.50)	4.44 (3.28)
	Central Europe	5.98 (4.96)	5.95 (4.93)	5.83 (4.84)	5.66 (4.70)	5.42 (4.50)

FEV_1 : MEAN VALUES AND 95% CONFIDENCE LIMIT

Height (m)		Age Group				
		20–	30–	40–	50–	60–
1.60	Greece	3.99 (3.24)	3.65 (2.89)	3.31 (2.54)	2.99 (2.20)	2.64 (1.84)
	U.S.A.	3.97 (2.93)	3.69 (2.65)	3.41 (2.37)	3.13 (2.09)	2.85 (1.81)
	Central Europe	3.35 (2.71)	3.26 (2.64)	3.10 (2.52)	2.92 (2.37)	2.67 (2.16)
1.70	Greece	4.60 (3.89)	4.24 (3.52)	3.88 (3.14)	3.52 (2.76)	3.16 (2.38)
	U.S.A.	4.34 (3.30)	4.06 (3.02)	3.78 (2.74)	3.50 (2.46)	3.22 (2.16)
	Central Europe	4.02 (3.26)	3.91 (3.17)	3.72 (3.01)	3.50 (2.83)	3.20 (2.59)
1.80	Greece	5.21 (4.50)	4.83 (4.10)	4.46 (3.69)	4.07 (3.26)	3.70 (2.85)
	U.S.A.	4.71 (3.67)	4.43 (3.39)	4.15 (3.11)	3.87 (2.83)	3.59 (2.55)
	Central Europe	4.77 (3.86)	4.64 (3.76)	4.42 (3.58)	4.16 (3.37)	3.80 (3.08)

Thus at 50 or 60 years the Greek and U.S. values are almost the same. It is nevertheless worthwhile noticing that, in general, the FEV₁ values for the three populations do not differ significantly.

Our findings suggest, therefore, that the Greek mean values are slightly higher than those for the U.S. The reason is not clear. Possibly our criteria of selection were more severe, as we selected subjects who had had no chest illness within the previous three years, whereas Kory *et al.* (1961) discarded only those subjects with a history of chest disease during the six months preceding the test. Another possible reason may be that our subjects were living in areas where air pollution is considered to be low. Recent studies (Alivizatos, Bazas, Alexopoulos, and Verikokakis, 1965, 1968) have shown that heavy air pollution is limited to the central commercial area of Athens where none of our subjects was living permanently. On the other hand, tobacco consumption cannot be taken into consideration as neither this work nor that of Kory *et al.* distinguished between smokers and non-smokers. Moreover, its influence on spirometric values is uncertain (Cotes *et al.*, 1964).

Although there is serious statistical criticism of the use of lower limits of normal as reference points for lung function assessment¹, the figures given in Table II seem to be valuable in clinical practice. Moreover, the lower limits have been proved to be useful in daily clinical practice and this is the main reason for their continued use.

Many thanks are due to Dr. J. E. Cotes for considerable help throughout this study.

REFERENCES

- Alivizatos, G. P., Bazas, B. N., Alexopoulos, G., and Verikokakis, E. (1965). The problem of air pollution in the city and greater Athens. *Arch. Hyg. (Athinae)*, **15**, 329. (In Greek; Eng. summary, p. 392).
- (1968). The problem of air pollution in Athens and surrounding territory. Part II. *Arch. Hyg.*, **18**, 1. (In Greek; Eng. summary, p. 20).
- Baldwin, E. de F., Cournand, A., and Richards, D. W. (1948). Pulmonary insufficiency. I. Physiological classification, clinical methods of analysis, standard values in normal subjects. *Medicine (Baltimore)*, **27**, 243.
- Berglund, E., Birath, G., Bjure, J., Grimby, G., Kjellmer, I., Sandqvist, L., and Söderholm, B. (1963). Spirometric studies in normal subjects. I. Forced expirograms in subjects between 7 and 70 years of age. *Acta med. scand.*, **173**, 185.
- Commission des Communautés Européennes. Tables de références pour les examens spirographiques. Luxembourg, 1967.
- Cotes, J. E. (1965). *Lung Function*. Blackwell, Oxford.
- Higgins, I. T. T., Rossiter, C. R., and Wilton, C. (1964) (unpublished). Normal values for the forced expiratory volume in British males analysed by age, height and tobacco consumption. Account of surveys in different parts of the U.K. by the Pneumoconiosis Research Unit of M.R.C.
- Kory, R. C., Callahan, R., Boren, H. G., and Syner, J. C. (1961). The Veterans Administration-Army cooperative study of pulmonary function. I. Clinical spirometry in normal men. *Amer. J. Med.*, **30**, 243.
- McKerrow, C. B., McDermott, M., and Gilson, J. C. (1960). A spirometer for measuring the forced expiratory volume with a simple calibrating device. *Lancet*, **1**, 149.

¹International Symposium on Respiratory Physiology, Sassari, May 1969