Peak flow rate in Nigeria :

Anthropometric determinants and usefulness in assessment of ventilatory function

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The inexpensive nature of the peak flow rate (PFR) makes it a suitable test of ventilatory function for use in some parts of Africa, where medical facilities are still poor. In order to establish standard values for PFR in Nigeria, anthropometric measurements, lung volumes, and PFR were obtained from 142 men and 88 women, all of whom were healthy Nigerians. The mean values of PFR were 482.1 l/min (± 83.3) for males (average age 34.9 years) and 385.6 l/min (± 65.7) for females (average age 29.4 years), both means being significantly lower than corresponding means of predicted values calculated from formulae based on previously reported studies of Caucasians. PFR was correlated with age, various physical measurements, and lung volumes. The combination of age and height gave the regression equation for predicting PFR with the lowest standard error of estimates; and virtually all lung volumes measured correlated significantly with PFR. In 16 adult Nigerian asthmatics, PFR correlated significantly with vital capacity, forced expiratory volume (1 second), and expiratory reserve volume; it was highest in those who had no symptomatic or spirometric signs of any ventilatory defect, and lowest in those who had signs of both obstructive and restrictive defects.

There have been few studies of pulmonary function among Africans, almost certainly due to lack of the relatively sophisticated and expensive equipment required. A simple, easy, reliable and inexpensive test of lung function will therefore be useful for both clinical and epidemiological investigations in those parts of Africa where medical facilities are still meagre and rudimentary. The Wright peak flow meter (Wright and McKerrow, 1959) provides such a test. We have tried to establish 'normal' values for peak flow rate (PFR) among healthy adult Nigerians so as to introduce it into clinical practice in Nigeria, and possibly other parts of Africa. Here we present the values obtained from 142 men and 88 women and describe the relationship of these values to the physical characteristics and lung volumes of the subjects studied. Our work was carried out in conjunction with a comprehensive study of ventilatory function in healthy adult Nigerians (Femi-Pearse and Elebute, 1971). In order to determine the usefulness of the standard values of PFR obtained from studying healthy subjects, they have been compared with PFR in adult Nigerian asthmatics.

MATERIALS AND METHODS

Anthropometric measurements, lung volumes, and PFR were obtained from 230 healthy Nigerian subjects living in Lagos, the capital and main port of Nigeria. There were 142 men and 88 women. The subjects were distributed uniformly between the age group 17 to 19 and five-year age groups from 20 to 54 in men and 20 to 44 in women. Older subjects were not readily available for study. All subjects appeared healthy, none had been exposed to dusty occupations, all were drawn from institutions which had efficient medical care for their staff, and most were employees of the Nigerian Railway Corporation working as accounting and printing executives, clerks, and cooks. There were no engine drivers nor firemen among them. A few were medical students and hospital employees of Lagos University Teaching Hospital.

The following criteria were required for acceptance as a 'normal' subject:

- (1) no history of cardiopulmonary disease;
- (2) capacity to co-operate adequately during the tests;
- (3) no evidence or history of disease which might affect pulmonary function.

These standards were similar to those set out by the

Veterans Administration—Army Co-operative study of pulmonary function (Kory, Callahan, Boren, and Syner, 1961), except that chest radiographs were not obtained at the time of the study. However, a normal chest film is a prerequisite of employment at both the Nigerian Railway Corporation and Lagos University Teaching Hospital.

Anthropometric measurements were obtained as follows:

Height without shoes, weight with minimal clothing, chest expansion, and abdominal circumference at the umbilicus at end-tidal expiration.

The Wright peak flow meter was used to measure PFR. Only one meter was employed for all the determinations, and it had been calibrated from the factory. Each subject had five determinants of PFR after being fully instructed about the details of the manoeuvre. The best determination was recorded at ambient temperature and pressure saturated with water vapour (ATPS). Vital capacity (VC), forced expiratory volume in one second (FEV₁), inspiratory capacity (IC), expiratory reserve volume (ERV), functional residual capacity (FRC), and total lung capacity (TLC) were also measured in each subject and recorded at body temperature and pressure saturated with water vapour (B.T.P.S.). The details of the methods employed to measure these lung volumes have already been described elsewhere (Femi-Pearse and Elebute, 1971). Statistical analysis of the data obtained was carried out with the help of an IBM 1620 computer. PFR was correlated with anthropometric measurements and lung volumes. Regression equations were then calculated for predicting PFR from anthropometric measurements and for predicting lung volumes from PFR. Using the Student's *t* test, the mean PFR of our subjects was compared with the mean of predicted values calculated from formulae which had been previously reported in the literature.

In the other part of the study, PFR was determined in 16 adult Nigerian asthmatics, nine men and seven women. The determinations were compared with predicted normal values calculated with the aid of regression equations which gave the lowest standard error of estimates in the study of healthy individuals, and with other ventilatory data obtained from the asthmatics.

RESULTS

The mean values of PFR for the persons studied were 482.1 l/min (± 83.3) for men and 385.6 l/min (± 65.7) for women. The mean predicted values derived from the formulae based on age and height of Americans studied by Leiner *et al.* (1963) were 578.5 ± 39.9 for men and 436.9 ± 23.5 for women. For both men and women the observed values were significantly lower than the predicted values ($P < 0.0001$). Table I presents a

comparison of mean PFR of five-year age groups from 30 to 59 years among Londoners studied by Tinker (1961) and Nigerians. PFR is clearly lower among Nigerians than in the British.

TABLE I

COMPARISON OF MEAN PFR (l/min) OF VARIOUS AGE GROUPS AMONG NIGERIAN AND BRITISH MEN

Age Group	Nigerian (Present study)	British (Tinker, 1961)
30-34	471	622
35-39	496	586
40-44	467	583
45-49	475	552
50-54	424	496
55-59	405	517

Tables II and III show the correlation of PFR with various anthropometric measurements and lung volumes in men and women, respectively. In both men and women there is a statistically significant negative correlation with age. In men, the correlation coefficients with height and weight

TABLE II

CORRELATION OF PFR WITH PHYSICAL CHARACTERISTICS AND LUNG VOLUMES IN 142 NIGERIAN MEN

	Mean	S.D.	Correlation Coefficient with PFR	P
Age (yr)	34.9	12.0	-0.310	<0.001
Height (cm)	168.1	6.6	0.329	<0.001
Weight (kg)	65.7	10.0	0.181	<0.05
Chest expansion (mm)	30.7	9.0	0.013	N.S.
Chest circumference at expiration (cm)	82.1	6.6	0.156	N.S.
Abdominal circumfer- ence (cm)	77.1	9.5	-0.061	N.S.
VC (ml)	3354	600	0.475	<0.001
FEV ₁ (ml)	2704	699	0.494	<0.001
IC (ml)	2096	557	0.305	<0.001
ERV (ml)	1244	397	0.313	<0.001
FRC (ml)	2074	693	0.208	<0.05
TLC (ml)	4186	850	0.362	<0.001

N.S. = Not statistically significant.

TABLE III

CORRELATION OF PFR (l/min) WITH PHYSICAL CHARACTERISTICS AND LUNG VOLUMES IN 88 NIGERIAN WOMEN

	Mean	S.D.	Correlation Coefficient with PFR	P
Age (yr)	29.4	8.5	-0.509	<0.001
Height (cm)	161.1	6.9	-0.051	N.S.
Weight (kg)	62.2	12.7	-0.192	N.S.
Chest expansion (mm)	32.5	14.1	0.267	<0.05
Chest circumference at expiration (cm)	81.2	7.9	0.020	N.S.
Abdominal circumfer- ence (cm)	76.6	11.9	-0.353	<0.001
VC (ml)	2547	525	0.614	<0.001
FEV ₁ (ml)	2004	484	0.595	<0.001
IC (ml)	1618	459	0.437	<0.001
ERV (ml)	922	309	0.372	<0.001
FRC (ml)	1655	658	0.122	N.S.
TLC (ml)	3276	745	0.360	<0.001

N.S. = Not statistically significant.

TABLE IV
FORMULAE FOR PREDICTING PFR FROM AGE, HEIGHT, AND WEIGHT OF ADULT NIGERIANS

Predictors Used	Sex	Coefficient for Age (yr)	Coefficient for Height (cm)	Coefficient for Weight (kg)	Constant	R ¹	S.E.E. ²
Age	M	-2.19	—	—	557.8	-0.310	81.0
	F	-3.88	—	—	498.4	-0.509	56.5
Height	M	—	4.23	—	-229.7	0.329	80.5
Weight	M	—	—	1.53	380.9	0.181	83.8
Age, Height	M	-1.73	3.47	—	-41.5	0.406	78.2
	F	-3.99	-1.07	—	673.2	-0.516	56.3
Age, Weight	M	-2.51	—	2.08	43.2	0.393	78.6
	F	-4.07	—	0.29	486.3	-0.502	56.7
Height, Weight	M	—	4.10	0.18	-218.6	0.330	80.8

¹ Correlation coefficient; where more than one independent variable is present, multiple correlation coefficient is given.

² Standard error of estimate.

are also significant, while in women there is a significant negative correlation with abdominal circumference. Table IV presents the regression formulae calculated for predicting PFR from age, height, and weight among adult Nigerians. The combination of age and height gave the formula with the lowest standard error of estimates.

In both men and women, PFR correlates significantly with all lung volumes with the exception of FRC in women. Tables V and VI present

TABLE V

CORRELATION OF PFR (l/min) WITH LUNG VOLUMES AND REGRESSION EQUATIONS FOR PREDICTING LUNG VOLUMES FROM PFR IN NORMAL NIGERIAN MEN

Lung Volume	Correlation Coefficient	Regression Coefficient	Regression Constant	S.E.E.
VC (ml)	0.475 ²	3.31	1774	531
FEV ₁ (ml)	0.494 ²	4.06	752	608
IC	0.305 ²	1.96	1162	535
ERV	0.313 ²	1.47	537	383
FRC	0.208 ¹	1.68	1262	692
TLC	0.362 ²	3.64	2441	799

¹ Significant at the 0.05 level.

² Significant at the 0.001 level.

TABLE VI

CORRELATION OF PFR (l/min) WITH LUNG VOLUMES AND REGRESSION EQUATIONS FOR PREDICTING LUNG VOLUMES FROM PFR IN NORMAL NIGERIAN WOMEN

Lung Volume	Correlation Coefficient	Regression Coefficient	Regression Constant	S.E.E.
VC (ml)	0.614 ¹	4.67	733	397
FEV ₁ (ml)	0.595 ¹	3.86	506	349
IC (ml)	0.437 ¹	3.00	473	409
ERV (ml)	0.372 ¹	1.64	266	275
FRC (ml)	0.122	—	—	—
TLC (ml.)	N.S.	—	—	—
	0.360 ¹	4.23	1617	726

¹ Significant at 0.001 level.

N.S. = Not significant.

the correlation coefficients of PFR with lung volumes as well as the regression equations for predicting lung volumes from PFR.

Table VII shows the correlation of PFR with physical measurements and lung volumes in 16 adult Nigerian asthmatics. Although the number of patients was small, a significant correlation was obtained between PFR and VC, FEV₁, and ERV. In Table VIII, the patients are grouped according to the severity of their symptoms and on the basis of their FEV₁% (FEV₁/FVC%) and their forced vital capacity (FVC), the latter being expressed as a percentage of the predicted value. FVC of more than 90% of the predicted value and FEV₁% of more than 70 were taken as 'normal'. A diminished FVC was assumed to be an indication of a restrictive ventilatory defect while a lowered FEV₁% indicated an obstructive defect. PFR (expressed as a percentage of predicted values) was highest in those asthmatics who had no symptomatic or spirometric signs of any ventilatory defect, and lowest in those who had signs of both obstructive and restrictive defects.

TABLE VII

CORRELATION OF PFR (l/min) WITH PHYSICAL CHARACTERISTICS AND LUNG VOLUMES IN ADULT NIGERIAN ASTHMATICS

	Mean	S.D.	Coefficient of Correlation with PFR	Significance of Correlation P
Age (yr)	33.5	10.5	-0.400	N.S.
Height (cm)	167.1	5.7	0.140	N.S.
Weight (kg)	59.6	8.5	0.117	N.S.
VC (ml)	2386	871	0.687	> 0.001
FEV ₁ (ml)	1041	455	0.823	> 0.001
ERV (ml)	785	443	0.660	> 0.01
FRC (ml)	2433	1001	0.170	N.S.
TLC (ml)	4035	1251	0.381	N.S.

N.S. = Not significant.

TABLE VIII
COMPARISON OF PFR WITH OTHER VENTILATORY DATA IN ADULT NIGERIAN ASTHMATICS

No. of Patients	Wheeze	FVC % Predicted	$\frac{FEV_1}{FVC}$ %	Type of Pulmonary Disease	PFR % Predicted
2	Absent	107.0 ¹	71.0	—	93.6
2	Present	72.3	71.0	Restrictive	72.1
2	Present	109.8	33.5	Obstructive	57.2
7	Present	73.1	50.6	Obstructive and restrictive	34.3
3	Audible to unaided ears	50.9	46.7	Obstructive and restrictive	29.3

¹ Figures represent average values.

DISCUSSION

The results presented in this study show that peak flow rate, determined with Wright's peak flow meter, is lower in Nigerians than in either Americans or the British. This is in agreement with the lower values of VC, FEV₁, and TLC which have been found in Nigerians as well as in other peoples of African descent (Abramowitz, Leiner, Lewis, and Small, 1965; Johannsen and Erasmus, 1968; Femi-Pearse and Elebute, 1971). No satisfactory explanation has been offered for racial variations of lung volumes. It is unlikely that these differences can be accounted for by a high prevalence of childhood respiratory infections as suggested by Glass (1962) in his comparison of Maoris with Caucasian New Zealanders. It is likely, however, that there are racial differences in thoracic cage size or shape. The racial differences in ventilatory capacity necessitate the calculation of different standard values for the various races. Tables of standard values of PFR and other lung volumes have been prepared for Nigerians and are being published elsewhere (Elebute and Femi-Pearse, 1971). The similarity of values obtained for lung volumes among Nigerians with those obtained in South African Bantus by Johannsen and Erasmus (1968) makes it likely that the tables prepared from data collected in Nigeria may be applicable to other Africans.

There is a positive correlation between PFR and VC or FEV₁. This correlation has been reported previously by several authors and is known to occur both in healthy individuals and in patients who have ventilatory defects (Prime, 1960; Ritchie, 1962; Fairburn, Fletcher, Tinker, and Wood, 1962; Leiner *et al.*, 1963). PFR can, therefore, be used in the assessment of patients with pulmonary disease. The values of PFR obtained in the presence of various types of ventilatory defect differ, but there is too much overlap

to permit a clear differentiation between restrictive and obstructive ventilatory defects. The lowest values of PFR are to be expected in the severer forms of respiratory disease in which there is a combination of obstruction and restriction of ventilation.

The simplicity of the peak flow test makes it particularly suitable for epidemiological studies of respiratory diseases (Ferris and Anderson, 1964; Toyama, 1964). Although some objection has been raised to the intrinsic validity of the peak flow test (Macklem and Mead, 1967), it is clear that in a population study this test will identify persons with gross ventilatory defects. Many inaccurate statements are made about the incidence in Africa of such diseases as asthma, chronic bronchitis, and emphysema. Population surveys of ventilatory function are, therefore, required in Africa; and the peak flow meter is conveniently portable and likely to be the most suitable instrument for such surveys.

The authors are grateful to Mr. E. O. Omo-Oso for technical assistance.

REFERENCES

- Abramowitz, S., Leiner, G. C., Lewis, W. A., and Small, M. J. (1965). Vital capacity in the Negro. *Amer. Rev. resp. Dis.*, **92**, 287.
- Elebute, E. A., and Femi-Pearse, D. (1971). Ventilatory function in Africans: tables of standard values in normal subjects. (In press.)
- Fairbairn, A. S., Fletcher, C. M., Tinker, C. M., and Wood, C. H. (1962). A comparison of spirometric and peak expiratory flow measurements in men with and without chronic bronchitis. *Thorax*, **17**, 168.
- Femi-Pearse, D., and Elebute, E. A. (1971). Ventilatory function in healthy adult Nigerians. (In press.)
- Ferris, B. G., Jr., and Anderson, D. O. (1964). Epidemiological studies related to air pollution: A comparison of Berlin, New Hampshire, and Chilliwack, British Columbia. *Proc. roy. Soc. Med.*, **57**, 979.
- Glass, W. I. (1962). Ventilatory function differences between Polynesian and European rope workers. *N.Z. med. J.*, **61**, 433.

- Johannsen, Z. M., and Erasmus, L. D. (1968). Clinical spirometry in normal Bantu. *Amer. Rev. resp. Dis.*, **97**, 585.
- Kory, R. C., Callahan, R., Boren, H. G., and Syner, J. C. (1961). The Veterans Administration—Army cooperative study of pulmonary function. 1. Clinical spirometry in normal men. *Amer. J. Med.*, **30**, 243.
- Leiner, G. C., Abramowitz, S., Small, M. J., Stenby, V. B., and Lewis, W. A. (1963). Expiratory peak flow rate. *Amer. Rev. resp. Dis.*, **88**, 644.
- Macklem, P. T., and Mead, J. (1967). The physiological basis of common pulmonary function tests. *Arch. environm. Hlth*, **14**, 5.
- Prime, F. J. (1960). Peak-flow meter. *Brit. med. J.*, **1**, 423.
- Ritchie, B. (1962). A comparison of forced expiratory volume and peak flow in clinical practice. *Lancet*, **2**, 271.
- Tinker, C. M. (1961). Peak expiratory flow measured by the Wright peak flow meter. *Brit. med. J.*, **1**, 1365.
- Toyama, T. (1964). Air pollution and its health effects in Japan. *Arch. environm. Hlth*, **8**, 153.
- Wright, B. M., and McKerrow, C. B. (1959). Maximum forced expiratory flow rate as a measure of ventilatory capacity. *Brit. med. J.*, **2**, 1041.