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Peak Flow Rate in Healthy School Children

WI ADERELE* AND O ODUWOLE**

Summary

Aderele WI and Oduwole O. Peak Flow Rate in Healthy School Children. *Nigerian Journal of Paediatrics* **1983**; **10**: **45**. Peak flow rate was determined in 1,387 apparently healthy school children, aged between 4 and 16 years. The results obtained were analysed with respect to the ages, heights, weights and body surface areas of the subjects. Since height, among the variables, correlated best with PFR values, equations have been produced, using height as the independent variable. Our results were similar to those reported from other parts of the world for subject heights, between 120cm and 150cm. However, between 90cm and 120cm, the values obtained in the present series were higher than those reported by others. Conversely, between subjects heights, 150cm-180cm, our values were lower. Peak flow rate values were higher in males than in females at ages 4-10 years; from ages 11 to 15 years, the values were higher in females. However, when values obtained in both sexes at similar heights were compared, there was a tendency for males to have higher values, at most of the heights. There was no consistent relationship between the family socio-economic status and the PFR values.

Introduction

ALTHOUGH most respiratory problems in childhood can be diagnosed and managed without pulmonary function tests, the latter add objective parameters to observable clinical phenomena and sometimes, reveal defects in certain aspects of lung function which are inaccessible to the ordinary clinical methods of examination.[1] For instance, in bronchial asthma, these tests are useful in assessing degrees of airway obstruction, quantitating airway hyperactivity and determining the acute effect of bronchodilator treatment. One of the simplest lung function tests available is the peak flow rate (PFR). This index of lung function is the maximum flow rate attainable at any time during a forced expiratory effort. In order to interpret PFR values obtained in patients with the above and related problems meaningfully, a thorough knowledge of the normal values is required. These values have been established for children elsewhere.[2–6] There have been only two previous studies of PFR in Africa and these concerned adolescents[7] and adults.[8]

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Since it has been established that there are variations in values of PFR in different racial and ethnic groups, [9 10] there is thus, the need to establish separate normal values for different racial or ethnic groups. The object of the present study was to determine normal values of PFR in Nigerian children.

Materials and Methods

The subjects consisted of apparently healthy school children of Yoruba ethnic group, from schools which were randomly selected from a list of schools in Ibadan. The eight schools selected comprised three fee-paying and privately owned schools attended by children whose parents were mainly from high and medium socio-economic groups; three state-owned and non-fee-paying schools with children whose parents were mostly of low and medium socio-economic status and two secondary schools with children from all socio-economic classes in the community.

From each class, names of 25–30 children were randomly selected from the register, using the odd and even number rule for different classes. For example, in the Nursery class of a school, the children whose names appeared opposite odd numbers in the register, were selected; in Kindergaten one, those names opposite even numbers were selected, while in Kindergarten two, odd number names were again selected. This mode of selection was repeated up to primary six. The same procedure was used with regards to the secondary schools. The children selected were examined clinically after which each was given a questionnaire to be completed by the parents. The questionnaire contained requests for information on the subject's age, address, parental educational attainments and occupations as well as any history of chronic cough or other respiratory or chronic problems in the subject and the family. Parental consent for the children to participate in the study was obtained. On the basis of the clinical examination and responses to the questionnaire, some children were excluded from the study. These included those with a personal or family history of acute or chronic cough and breathlessness; those with clinical evidence of respiratory, cardiac or other major systemic illness; those with chest deformities and those with psychological problems causing withdrawal effects and hence limited cooperation (e.g. failure in recent school examination).

The heights and weights of the children were obtained using techniques described by Falkner[11] and by Janes and Antia.[12] The adult type Wright Peak Flow Meter (Airmed, Sussex) was used to determine the peak flow rate. The technique in the measurement of the PFR was demonstrated many times before and during data collection to small groups of the subjects. The PFR was measured with subject standing, without nose clips and with lips firmly applied around the disposable cardboard mouthpiece; effort was made to ensure that there was no leakage around the mouthpiece. The subject was requested to take in a deep breath and to expire maximally, forcefully and rapidly into the instrument. The volume attained (in litres/minute) was read from the meter. Two practice attempts were made in each case. After being satisfied about a subject's capability of performing the test, three other readings were taken. The highest of the three values was taken as the peak flow rate. Faulty attempts, such as when a subject coughed into the flow meter or when he failed to apply the lips tightly around the mouthpiece were excluded. A separate disposable cardboard mouthpiece was used for each individual. For best instrumental efficiency the coarse-gauze mesh at the inlet nozzle of the flow meter was cleaned frequently to rid it of dust particles and large particles of sputum trapped in the gauze mesh.

The data obtained were analysed statistically, using a computer. Analysis of variance and test of significance were done using Student's 't' tests and F tests.

Results

PFR values were obtained from 1,387 healthy subjects (673 males and 714 females), aged between 4 and 16 years. The mean and standard deviation of the PFR values at different ages in both sexes, are presented in Table I. It is evident that the mean peak flow rate increased with age but was higher in males than in females between the ages of 4 and 10 years. However, the mean PFR in females between 12 and 15 years, was higher than that of the males of the same ages. At 16 years, the mean peak flow rate in males was higher than in females (Fig 1). Differences in the PFR values between the sexes were still obvious when the means and standard deviations at various grouped heights (Table II, Fig. 2) and weights (Table III, Fig. 3) were compared in both sexes. However, while the values were higher in the males at all comparative grouped weights except one, analysis of the values at various grouped heights showed a mixed picture with values for males being higher at most grouped heights and lower at others. The correlation between PFR and height, weight, age and surface area is shown in Table IV . The peak flow rate increased in a linear manner with increase in age, height, weight and surface area in both males and females. In males, PFR correlated best with height, (r=0.91099), followed by body surface area (r=0.90296), weight (r=87460) and age (r=0.86080). Similarly in females, the height gave the best correlation with PFR (r=0.91255) followed by body surface area (r=0.90416), age (r=0.88796) and weight (r=86987).

Table V shows the relationships between PFR, height, weight, age and body surface area with their gradients, intercepts and the standard errors of the gradients and intercepts. In view of the difference shown between the males and females, regression equations for PFR in both sexes are given by:

$y = a + bx \pm 2s$ where

y= PFR

a= regression intercept

b= regression gradient

x= measured variable (height, weight, age or body surface area) and

s= residual standard deviation after regression

Thus, using height as the measured continuous variable,

For males: PFR (litres/min) = 4.60 x Height (cm) — 334.99 ± 78.36

For females: PFR (litres/min) = 4.66 x Height (cm) — 348.78 ± 78.84

and using weight as the measured continuous variable

For males: PFR (litres/min) = 7.85 x Weight (kg) + 54.58 ± 88.58

For females: PFR (litres/min) = 6.87 x Weight (kg) + 69.25 ± 95.10

Figures 4 and 5 are graphs showing PFR values at different heights constructed on the basis of the above equations for males and females respectively, with ± 2 residual standard deviations, after regression. The use of multiple variables (weights, age, body surface area and height) in the regression equation did not improve the value of PFR significantly.

In the present study, the use of semilogarithmic coordinates for PFR gave a curve with the value not appreciably higher than using straight lines except at the height of 170cm. However, the PFR with the semilogarithmic coordinates incorporated 95% of the PFR observations as opposed to a lower percentage incorporation using straight lines. Using this semi-logarithmic coordinates with height as the measured variable, the equation was modified as follows:

$$\log_{10}(y) = a + b \log_{10}(\text{height in cms}) \pm 2SD$$

For males: $\log_{10}\text{PFR} = -2.67460 + 2.40132 \log_{10}(\text{height in cms}) \pm 2(0.06594)$

and *for females*: $\log_{10}\text{PFR} = -2.87562 + 2.49032 \log_{10}(\text{height in cms}) \pm 2(0.06887)$.

The graphic comparison of the values derived from the regression equations for PFR using height, in the present study and the corresponding equations obtained by workers from other parts of the world are presented in Fig. 6. The graph shows that apart from the PFR values reported in females by Chiang and Han,[13] there were no

TABLE I

Peak Flow Rate (litres/min) in 673 Males and 714 Females according to Age

Age (Years)	Males			Females		
	No. of Subjects	Mean	Standard Deviation	No. of Subjects	Mean	Standard Deviation
4	55	141.000	27.595	55	132.000	30.316
5	52	165.865	28.314	58	152.414	29.974
6	50	183.300	34.479	51	181.176	34.243
7	43	217.326	41.909	42	216.071	40.972
8	53	259.811	35.921	48	241.875	44.166
9	50	270.200	55.346	58	261.810	46.052
10	52	293.846	45.229	60	280.667	47.883
11	51	310.196	47.791	53	310.660	51.516
12	53	324.151	45.854	73	332.329	50.718
13	57	340.088	49.031	50	361.400	51.160
14	51	350.392	53.859	63	373.651	49.637
15	54	363.611	54.109	53	380.566	43.926
16	52	407.855	54.407	50	398.500	32.768

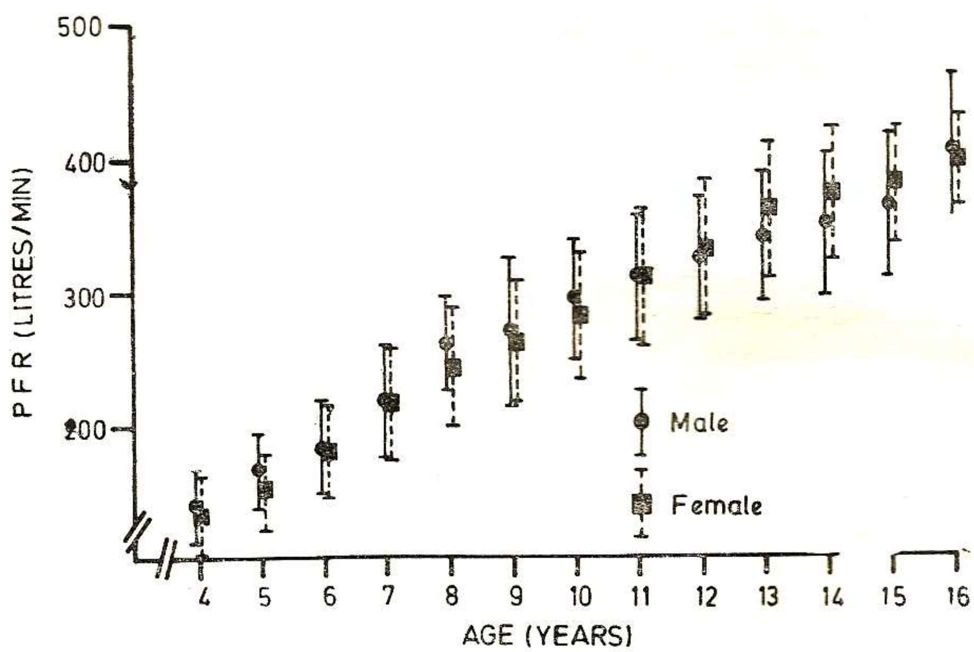

Fig. 1 Mean PFR ± 2 Standard Deviations in relation to age

TABLE II

Grouped Heights in Relation to Peak Flow Rate (litres/min) in 673 Males and 714 Females

Grouped Height (cm)	Males			Females		
	No. of Subjects	Mean	Standard Deviation	No. of Subjects	Mean	Standard Deviation
90–94.99	2	97.500	3.536	4	105.000	9.129
95–99.99	6	135.000	30.000	14	111.429	16.104
100–104.99	17	132.059	31.077	28	127.857	20.432
105–109.99	41	149.634	21.575	27	154.074	28.556
110–114.99	63	174.841	29.223	56	168.482	36.877
115–119.99	46	189.457	34.884	53	182.830	33.976
120–124.99	51	225.784	40.907	53	227.925	42.860
125–129.99	50	261.800	38.674	44	253.523	44.132
130–134.99	58	282.328	37.850	56	270.179	41.176
135–139.99	61	304.754	34.453	50	289.00	40.708
140–144.99	79	316.582	41.468	66	301.818	46.555
145–149.99	67	342.164	41.763	52	344.327	40.524
150–154.99	43	361.860	35.322	78	374.744	40.040
155–159.99	39	396.795	39.009	82	377.866	42.825
160–164.99	24	402.708	48.048	36	407.222	37.195
165–169.99	15	433.000	48.873	14	408.929	30.457
170–174.99	8	433.125	33.694	1	395.000	0.00
175–179.99	3	423.333	25.166			

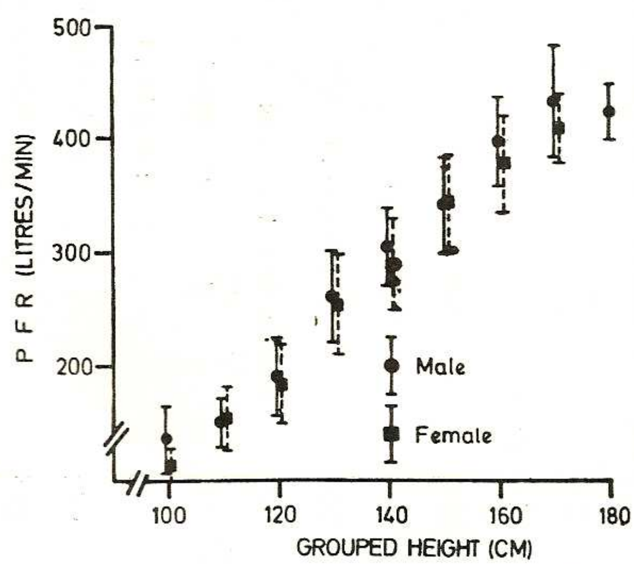

Fig. 2 *Mean PFR ± 2 Standard Deviations in relation to grouped heights.*

TABLE III

Grouped Weights in Relation to Peak Flow Rate (litres/min) in 673 Males and 714 Females

Grouped Weight (kg)	Males			Females		
	No. of Subjects	Mean	Standard Deviation	No. of Subjects	Mean	Standard Deviation
10—14.99	12	135.833	34.168	24	118.333	14.867
15–19.99	128	161.719	30.646	136	160.735	35.431
20–24.99	130	230.462	48.750	111	229.550	49.265
25–29.99	117	288.547	40.242	106	273.962	44.017
30–34.99	107	324.159	38.939	80	307.188	43.209
35–39.99	75	345.667	41.706	61	349.016	43.769
40–44.99	43	385.000	40.282	77	375.000	39.603
45–49.99	29	399.483	42.497	59	382.797	45.222
50–54.99	21	426.905	42.411	38	395.395	42.607
55–59.99	10	433.500	48.480	13	400.000	46.278
60–64.99	1	450.00	0.000	7	414.286	35.406
65–69.99	—	—	—	1	410.000	0.000
70–74.99	—	—	—	1	400.000	0.000

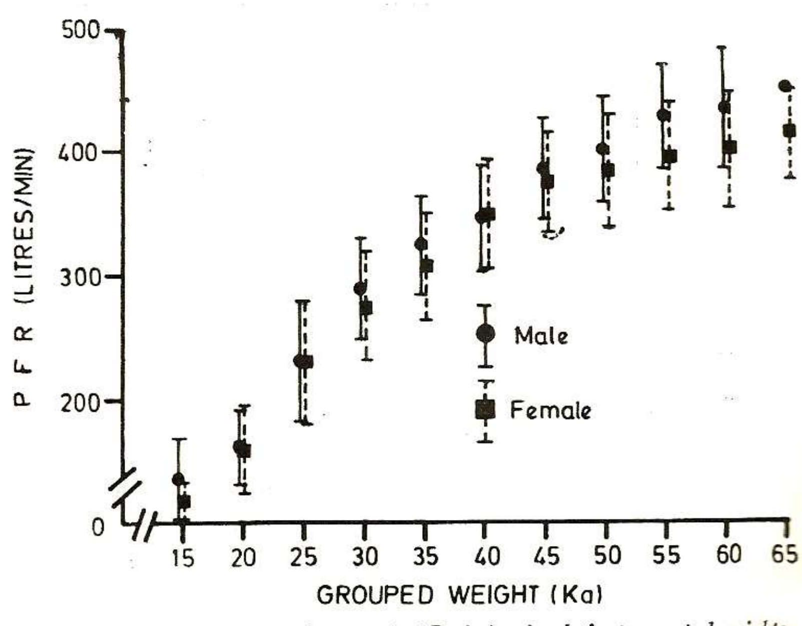

Fig. 3 Mean PFR ± 2 Standard Deviations in relation to grouped weights.

TABLE IV

Correlation Co-efficients between PFR, Height, Weight, Age and Surface Area

Males

	PFR	*Height*	*Weight*	*Age*	*Body Surface Area*
PFR	1.000	0.91099	0.87460	0.86080	0.90296
Height	—	1.000	0.94217	0.92216	—
Weight	—	—	1.000	0.86948	—
Age	—	—	—	1.000	—

Females

	PFR	*Height*	*Weight*	*Age*	*Body Surface Area*
PFR	1.000	0.91255	0.86987	0.88796	0.90416
Height	—	1.000	0.92874	0.93117	—
Weight	—	—	1.000	0.88149	—
Age	—	—	—	1.000	

TABLE V

Relationship between PFR, Height, Weight, Age and Surface Area

Males

	Number of Subjects	*Gradient*	*Standard Error of Gradient*	*Intercept*	*Standard Error of Intercept*
PFR and Height	673	4.60224	0.09365	−334.99051	12.63140
PFR and Weight	673	7.85449	0.19571	54.57757	5.96166
PFR and Age	673	20.85522	0.55422	70.49731	5.94939
PFR and Body Surface Area	673	0.03254	0.0007	−57.69066	7.43836

**Regression Equation:* $PFR = -334.99051 + 4.60224\ H \pm 2(37.67964)$

Females

	Number of Subjects	*Gradient*	*Standard Error of Gradient*	*Intercept*	*Standard Error of Intercept*
PFR and Height	714	4.66491	0.09350	−348.77758	12.73996
PFR and Weight	714	6.87311	0.17431	69.24929	5.76926
PFR and Age	714	23.08069	0.53463	47.91149	5.74564
PFR and Body Surface Area	714	0.03066	0.00065	−48.58966	7.19838

**Regression Equation:* $PFR = -348.77758 + 4.66491\ H \pm 2(39.42284)$

H = Height in centimetres
* Equations given for Height alone, since it correlated best with PFR.
Body Surface Area is in square centimetres.

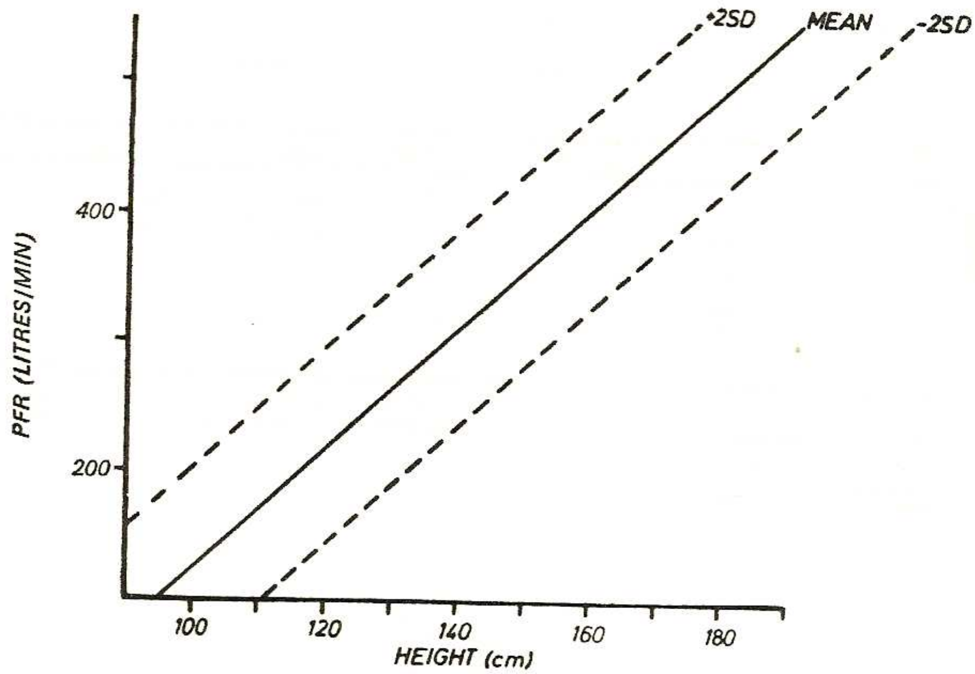

Fig. 4 *Predicted PFR values at different heights in males*

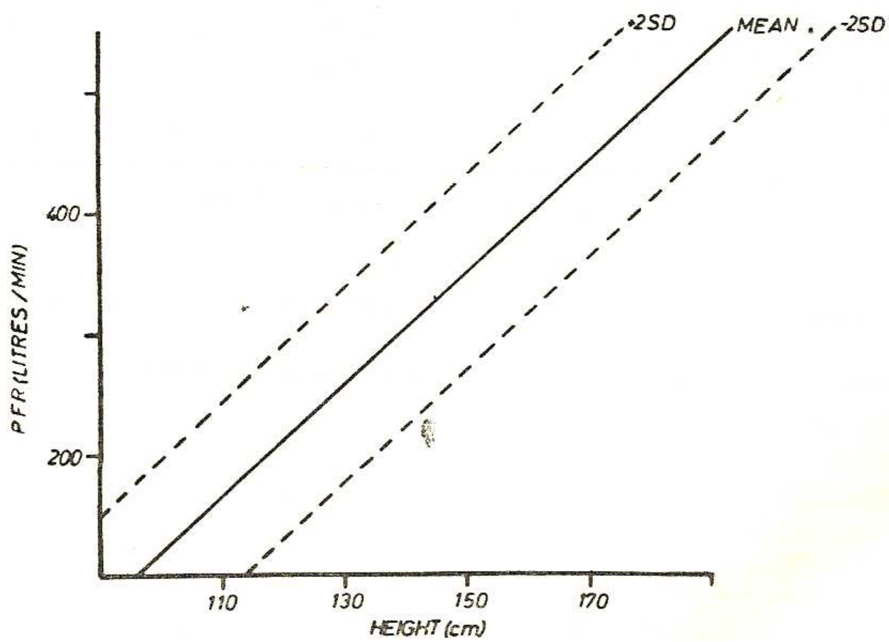

Fig. 5 *Predicted PFR values at different heights in females*

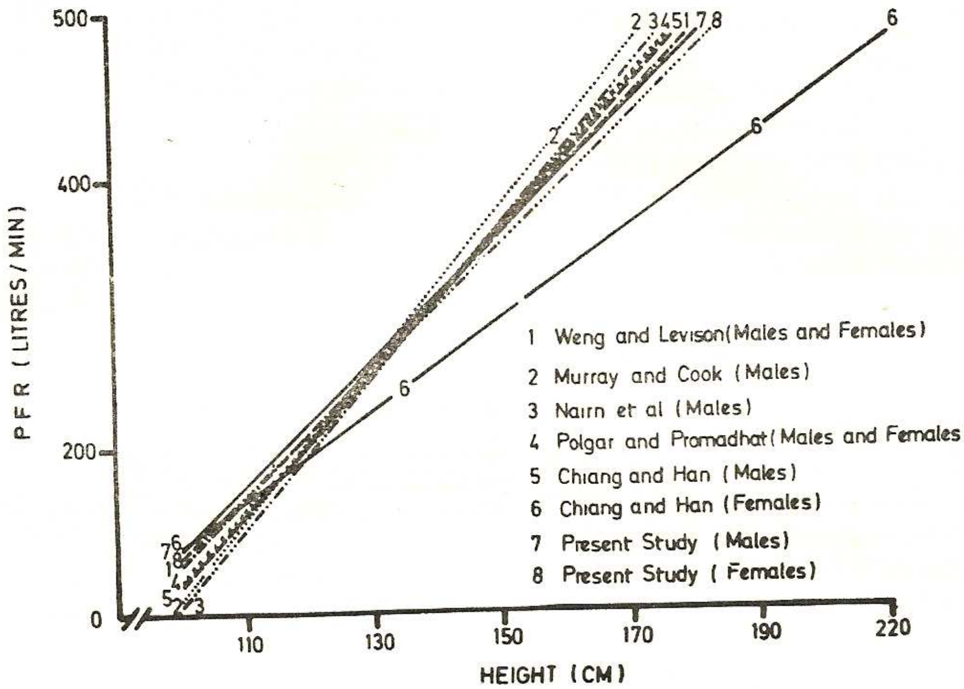

Fig. 6 Comparative PFR values by various workers.

marked differences in the values obtained by various workers[2-4 13 14] at heights, 130-150cm. However, outside this range, there were some divergencies, with our results showing higher values at heights below 130cm and lower ones at heights above 150cm.

Effect of socio-economic status

Analysis of the PFR values according to the parental socio-economic groups (based on the classification used at the Institute of Child Health and the Department of Preventive and Social Medicine, University of Ibadan), revealed inconsistent differences in PFR values among the various groups. These differences were least with values obtained at same heights and weights and most marked when values were related to ages. These differences were however, not significant enough to affect the use of the same regression equations for all socio-economic groups, when heights and weights are used as the measured variables.

Discussion

Of all the variables (height, age, weight and surface area) examined in the present study, height correlated best with PFR values. This observation is in keeping with that of other workers.[3-6] Furthermore, height can be accurately measured without the use of special equipment or technique; it is also less frequently below normal than is weight, with chest diseases.[15] It is therefore, best to use regression equations with height as the measured continuous variable for predicting PFR values.

Several workers from Europe and America have reported on normal values for PFR in children.[3-6 9 10] Most of these workers have produced regression equations for this index but because of reported racial and ethnic differences in these values,[9 10] such normal values cannot be assumed to be applicable to Nigerian children. Because of this, regression equations applicable to children of the Yoruba ethnic group have been produced, *based on the data obtained from the present* study. Compared with the normal values obtained by workers outside Africa, the present values for PFR were strikingly lower at subject heights above 150cm in both sexes. It is difficult to explain this observed differences, but it may be partly related to differences in socio-economic status which, as indicated by the present study has some minor effects on PFR values. Although there is at present, no definite proof that genetic variation has a direct effect on indices of lung function among different races, racial and genetic variations in thoracic cage shape and size have been suggested as the causes of racial variation in ventilatory indices.[16] Damon,[9] for instance, has suggested that the lungs of negroes may be smaller than those of caucasians but he has also admitted that no data on racial differences in weight of the lungs are available.

As shown in the present study and in consonance with reports by others,[2-6] PFR increased with age and anthropometric measurements, especially the height. Furthermore, there were differences between the values in both sexes, with males having higher values at younger ages and the females tending to have higher values between the ages of 12 and 15 years. The latter differences was probably due to earlier ages of attaining puberty and therefore, particular heights in females. When the PFR was standardized for height however, males tended to have higher values than females at most heights.

There is a paucity of information on normal values of pulmonary function tests in African children. It is however, possible that there would be minor variations in different parts of the continent, as a result of differences in the socio-economic status of parents which in turn might affect growth patterns in these children. In view of these possible variations, caution should be exercised in applying values obtained from the present study in areas where the children show obvious deficiency of height and weight in relation to their ages.

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