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A study of respiratory function in normal schoolchildren in northern Nigeria

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Summary

Respiratory function tests have been performed on schoolchildren in Zaria, Nigeria, to determine normal values among healthy children. Three hundred and eighty-eight students, comprising 257 male and 131 female children, from the Government Day Secondary School were included in this study. The forced vital capacity (FVC), forced expiratory volume in 1 sec (FEV_1), forced mid-expiratory flow (FMF 25–75%) and forced expiratory flow were measured using the vitalograph apparatus. It was observed from the results that the mean values of respiratory function tests in boys were significantly higher ($P < 0.01$) than the mean values matched for age, height and weight in female children. It was also observed that the values obtained in the present study were lower than those for Caucasian children. However, it was observed that FVC, FEV_1 and FMF 25–75% correlated significantly with age, height, weight and body surface area.

Résumé

Des tests de la fonction respiratoire ont été effectués sur les petits élèves à Zaria, au Nigéria, dans le but de définir les valeurs normales parmi les enfants bien-portants. Trois cents quatre-vingt-huit élèves, dont 257 garçons et 131 filles, de Government Day Secondary School ont été inclus dans cette étude. La capacité vitale forcée (FVC), le volume expiratoire forcé par seconde (FEV_1) l'écoulement expiratoire moyen forcé (FMF 25–75%) et l'écoulement expiratoire forcé, ont été mesurés au moyen du dispositif vitalographique. Les résultats ont montré que les valeurs moyennes des tests de la fonction respiratoire chez les garçons ont été, de manière significative, plus élevées ($P < 0.01$) que les valeurs moyennes calculées pour l'âge, la taille, et le poids chez les filles. Il a été également remarqué que les valeurs obtenues dans la présente étude ont été moins élevées que celles qui avaient été définies pour les jeunes Caucasiens. Cependant, il a été observé que FVC, FEV_1 et FMF 25–75% sont, très sensiblement, en corrélation avec l'âge, la taille, le poids et la mesure de la superficie du corps.

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Introduction

Respiratory function tests enable a better understanding of pulmonary physiology in subjects of all age groups, sex, profession, and occupation. They provide an understanding of functional changes in the lungs and a significant aid to diagnosis in chronic obstructive lung disease [1].

Reports on respiratory function studies have been scanty in African countries, particularly in Nigeria. Although there are a few published data [1–4] on ventilatory function tests in Nigerians these reports mainly concern the adult population.

Lung function measurements are made from time to time in Nigerian children with respiratory disorders and values from Caucasian children are used as an index of normality since there are no records of spirometric studies to determine a range of normal values. However, this is unsatisfactory as it has been reported that children of negroid origin have lower values than their Caucasian counterparts [5–7].

Therefore an attempt is made to establish a range of normal values of some respiratory function tests in normal schoolchildren from the northern savannah region of Nigeria.

Subjects and methods

The subjects studied were normal healthy children with ages ranging from 12 to 20 years from the Government Day Secondary School, Zaria, Nigeria. Pilot studies were carried out from a mixed ethnic group comprising 431 students but it was found necessary to restrict our studies to one major ethnic group, namely Hausa; from northern Nigeria, in order to eliminate the effects of extraneous variables. Hence, this study covers 388 subjects comprising 257 male and 131 female children. The sex ratio was low due to social customs of this region; however, we have not been selective on this basis. The sample for this study has been made representative of the population of schoolchildren in this region as much as possible.

The following criteria were required for acceptance as normal subjects: (1) no history of cardio-pulmonary disease, (2) capacity to co-operate adequately during the test, and (3) no evidence or history of disease which might affect pulmonary function.

The standards were similar to those set out by the Veterans Administration–Army Co-operative Study of Pulmonary Function [8], except that chest radiographs were not obtained in this study.

The subjects' standing height was measured without shoes, their body weight determined, and then body surface area was calculated.

All tests were performed in standing position using the single breath vitalograph (Vitalograph Limited, Buckingham, U.K.). Each test was performed three times and the curve with the highest FEV_1 was selected. Lung volumes were correlated to body temperature and pressure saturated with water vapour (BTPS). The respiratory tests consisted of FVC, FEV_1, FMF 25–75% and $FEF_{200-1200}$ (l/Hz).

Results

The age and sex distribution of the 388 children included in the study are shown in Table 1.

Table 1. Age and sex distribution of subjects

Age (years)	Male		Female		Total	
	n	%	*n*	%	*n*	%
12	24	6.20	23	5.4	47	12.1
13	29	7.50	17	4.4	46	11.9
14	33	8.50	20	5.2	53	13.7
15	28	7.20	22	5.7	50	12.9
16	59	15.20	21	5.4	80	20.6
17	36	9.30	28	7.2	64	16.5
18	14	3.60	0		14	3.6
19	18	4.60	0		18	4.6
20	16	1.50	0		16	4.1

Table 2 gives a summary of the means and standard deviations of measured variables. The male children have significantly higher mean values ($P < 0.01$) for FVC, FEV_1, FMF, and FEF in comparison to female children.

Table 3 shows mean values and standard deviations of various respiratory function tests by age for male children. It was noted that there was a linear relationship between measured variables and age.

Table 4 shows mean values and standard deviations of measured variable by age in female children. Linear relationships were observed between various respiratory function tests and age.

The mean values and standard deviations of lung functions tests by height for male children are shown in Table 5 and for female children in Table 6.

Table 2. Values for measured variables

Variables	Male		Female	
	Mean	s.d.	Mean	s.d.
Age (years)	15.87	1.69	15.27	1.69
Height (cm)	164.21	9.53	159.67	9.53
Weight (kg)	51.66	8.46	52.26	8.48
BSA (m^2)	1.55	0.16	1.52	0.16
FVC (l)	3.09	0.68	2.69	0.68
FEV (l)	2.61	0.65	2.30	0.65
FMF (l/Hz)	1.59	0.37	1.33	0.37
FEF (l/Hz)	4.51	1.70	3.94	1.70

Table 3. Mean values and standard deviations of respiratory function tests by age in male children

Age (years)	FVC (l)	FEV_1 (l)	FMF 25–75% (l/Hz)	FEF 200–1200 (l/Hz)
12	1.83 ± 0.30	1.57 ± 0.33	1.41 ± 0.42	4.06 ± 2.13
13	2.44 ± 0.69	2.02 ± 0.71	1.43 ± 0.51	4.17 ± 1.46
14	2.56 ± 0.50	2.06 ± 0.60	1.44 ± 0.38	4.37 ± 1.51
15	3.07 ± 0.55	2.55 ± 0.48	1.53 ± 0.27	4.41 ± 1.94
16	3.16 ± 0.52	2.69 ± 0.49	1.57 ± 0.26	4.42 ± 1.63
17	3.37 ± 0.40	2.93 ± 0.61	1.66 ± 0.21	4.61 ± 1.69
18	3.44 ± 0.44	3.06 ± 0.40	1.72 ± 0.22	4.83 ± 1.80
19	3.49 ± 0.79	3.06 ± 0.46	1.75 ± 0.22	5.32 ± 2.20
20	3.51 ± 0.40	3.11 ± 0.51	1.77 ± 0.43	6.09 ± 1.84

Table 4. Mean values and standard deviations of respiratory function tests by age in female children

Age (years)	FVC (l)	FEV_1 (l)	FMF 25–75% (l/Hz)	FEF 200–1200 (l/Hz)
12	2.38 ± 0.16	1.90 ± 0.23	1.18 ± 0.08	4.08 ± 0.87
13	2.39 ± 0.34	1.93 ± 0.23	1.19 ± 0.18	4.10 ± 1.04
14	2.40 ± 0.64	2.04 ± 0.23	1.20 ± 0.32	4.12 ± 1.07
15	2.41 ± 0.36	2.07 ± 0.46	1.22 ± 0.20	4.20 ± 1.74
16	2.75 ± 0.66	2.48 ± 0.56	1.36 ± 0.33	4.53 ± 1.78
17	2.98 ± 0.44	2.52 ± 0.38	1.48 ± 0.21	5.09 ± 2.48

Table 5. Mean values and standard deviations of respiratory function tests by height in male children

Height (cm)	FVC (l)	FEV_1 (l)	FMF 25–75% (l/Hz)	FEF 200–1200 (l/Hz)
140	2.01 ± 0.26	1.65 ± 0.41	1.26 ± 0.39	3.25 ± 0.80
145	2.09 ± 0.22	1.72 ± 0.29	1.30 ± 0.45	3.82 ± 1.05
150	2.51 ± 0.30	2.08 ± 0.34	1.31 ± 0.24	4.20 ± 1.07
155	2.65 ± 0.48	2.21 ± 0.49	1.47 ± 0.69	4.23 ± 1.64
160	3.05 ± 0.46	2.62 ± 0.41	1.51 ± 0.23	4.50 ± 1.72
165	3.25 ± 0.58	2.69 ± 0.59	1.67 ± 0.34	4.50 ± 1.82
170	3.48 ± 0.54	3.00 ± 0.53	1.72 ± 0.28	4.52 ± 1.79
175	3.53 ± 0.36	3.04 ± 0.61	1.79 ± 0.20	4.72 ± 1.60
180	3.62 ± 0.60	3.09 ± 0.45	1.81 ± 0.29	4.90 ± 1.86
185	5.10 ± 0.00	3.90 ± 0.00	2.55 ± 0.00	5.16 ± 0.00

Table 6. Mean values and standard deviations of respiratory function tests by height in female children

Height (cm)	FVC (l)	FEV_1 (l)	FMF 25–75% (l/Hz)	FEF 200–1200 (l/Hz)
140	2.05 ± 0.00	1.80 ± 0.00	1.00 ± 0.00	2.35 ± 0.00
145	2.16 ± 0.39	1.82 ± 0.25	1.08 ± 0.20	3.27 ± 0.46
150	2.40 ± 0.28	1.87 ± 0.34	1.20 ± 0.14	3.50 ± 0.46
155	2.72 ± 0.61	2.36 ± 0.47	1.34 ± 0.31	3.63 ± 1.64
160	2.78 ± 0.45	2.38 ± 0.48	1.38 ± 0.22	3.92 ± 1.84
165	2.81 ± 0.47	2.44 ± 0.38	1.38 ± 0.22	4.10 ± 1.23
170	3.65 ± 0.00	2.65 ± 0.21	1.79 ± 0.09	4.38 ± 2.02

Tables 7 and 8 show mean values and standard deviations of respiratory function tests by weight in male and female children, respectively.

Tables 9 and 10 show mean values and standard deviations of various respiratory function tests by body surface area in male and female children, respectively.

Correlation coefficients between lung functions and physical characteristics are shown in Table 11.

Discussion

It was observed that children of both sexes show a positive and significant correlation ($P < 0.01$) between age and various lung function tests. However, it is interesting to note that girls of 12 years of age had higher values of respiratory function measurements compared to boys of the same age group. On close examination it was found that girls of this particular age group were taller and heavier and had larger body surface areas than the boys. Therefore, the higher values of various respiratory function tests might be due to higher values of various physical characteristics.

There were positive and significant relationships ($P < 0.01$) between most respiratory function tests and height, weight and body surface area in both male and female children.

When a comparison of various respiratory tests was made between children of both sexes it was found that boys had significantly higher values ($P < 0.01$) of various respiratory function tests than girls.

In the past, only a few of the respiratory function tests such as FVC and FEV_1 for schoolchildren have been reported from southern

Table 7. Mean values and standard deviations of respiratory function tests by weight in male children

Weight (kg)	FVC (l)	FEV_1 (l)	FMF 25–75% (l/Hz)	FEF 200–1200 (l/Hz)
36	2.14 ± 0.21	1.78 ± 0.35	1.24 ± 0.36	4.05 ± 1.57
40	2.38 ± 0.41	2.00 ± 0.47	1.37 ± 0.16	4.15 ± 1.66
44	2.77 ± 0.31	2.32 ± 0.38	1.48 ± 0.23	4.20 ± 1.18
48	2.98 ± 0.45	2.59 ± 0.45	1.48 ± 0.67	4.22 ± 1.15
52	3.26 ± 0.50	2.78 ± 0.53	1.62 ± 0.26	4.35 ± 1.63
56	3.40 ± 0.44	2.82 ± 0.58	1.66 ± 0.26	4.63 ± 1.67
60	3.68 ± 0.54	3.00 ± 0.51	1.83 ± 0.30	4.76 ± 2.42
64	3.68 ± 0.64	3.00 ± 0.55	1.83 ± 0.30	4.76 ± 1.95
68	4.59 ± 0.54	3.86 ± 0.27	2.30 ± 0.26	5.39 ± 0.87

Table 8. Mean values and standard deviations of respiratory function tests by weight in female children

Weight (kg)	FVC (l)	FEV_1 (l)	FMF 25–75% (l/Hz)	FEF 200–1200 (l/Hz)
36	2.30 ± 0.31	1.97 ± 0.19	1.14 ± 0.18	2.78 ± 0.53
40	2.40 ± 0.30	2.01 ± 0.33	1.18 ± 0.14	3.03 ± 1.44
44	2.53 ± 0.67	2.28 ± 0.66	1.24 ± 0.33	3.51 ± 0.94
48	2.63 ± 0.66	2.30 ± 0.62	1.36 ± 0.32	3.55 ± 2.10
52	2.76 ± 0.23	2.32 ± 0.38	1.37 ± 0.11	3.60 ± 1.78
56	2.89 ± 0.62	2.42 ± 0.20	1.44 ± 0.31	3.72 ± 1.78
60	2.91 ± 0.64	2.53 ± 0.53	1.44 ± 0.33	4.55 ± 2.10
64	2.95 ± 1.01	2.54 ± 0.73	1.45 ± 0.49	4.69 ± 2.09
68	3.65 ± 0.00	2.80 ± 0.00	1.72 ± 0.00	5.16 ± 0.00

Table 9. Mean values and standard deviations of respiratory function tests by body surface area in male children

Body surface area (m^2)	FVC (l)	FEV_1 (l)	FMF 25–75% (l/Hz)	FEF 200–1200 (l/Hz)
1.00	1.73 ± 0.32	1.33 ± 0.44	1.23 ± 0.35	3.88 ± 0.96
1.10	2.01 ± 0.11	1.61 ± 0.33	1.32 ± 0.55	4.19 ± 1.31
1.20	2.05 ± 0.23	1.64 ± 0.26	1.40 ± 0.50	4.30 ± 1.40
1.30	2.43 ± 0.32	2.02 ± 0.31	1.42 ± 0.33	4.30 ± 1.78
1.40	2.74 ± 0.46	2.36 ± 0.55	1.52 ± 0.19	4.50 ± 1.40
1.50	3.08 ± 0.39	2.59 ± 0.39	1.58 ± 0.29	4.62 ± 1.52
1.60	3.40 ± 0.52	2.89 ± 0.56	1.69 ± 0.28	4.71 ± 1.89
1.70	3.56 ± 0.54	3.00 ± 0.49	1.81 ± 0.30	4.79 ± 1.83
1.80	4.22 ± 0.50	3.59 ± 0.50	2.11 ± 0.25	5.54 ± 2.53
1.90	5.10 ± 0.00	3.90 ± 0.00	2.55 ± 0.00	5.55 ± 0.00

Table 10. Mean values and standard deviations of respiratory function tests by body surface area in female children

Body surface area (m^2)	FVC (l)	FEV_1 (l)	FMF 25–75% (l/Hz)	FEF 200–1200 (l/Hz)
1.20	2.13 ± 0.11	1.73 ± 0.11	1.05 ± 0.07	3.19 ± 1.31
1.30	2.39 ± 0.35	1.97 ± 0.25	1.19 ± 0.17	3.46 ± 1.46
1.40	2.45 ± 0.43	2.20 ± 0.42	1.21 ± 0.22	3.52 ± 1.66
1.50	2.78 ± 0.46	2.37 ± 0.42	1.38 ± 0.23	3.86 ± 1.99
1.60	2.88 ± 0.61	2.49 ± 0.52	1.43 ± 0.29	3.91 ± 1.90
1.70	3.18 ± 0.87	2.58 ± 0.58	1.56 ± 0.42	4.59 ± 1.61

Table 11. Correlation coefficients of physical characteristics and lung function measurements

	Male				Female			
	Age (years)	Height (cm)	Weight (kg)	BSA (m^2)	Age (years)	Height (cm)	Weight (kg)	BSA (m^2)
FVC (l)	0.54*	0.66*	0.78*	0.76*	0.44*	0.45*	0.47*	0.48*
FEV_1 (l)	0.58*	0.59*	0.70*	0.72*	0.48*	0.44*	0.38*	0.45*
FMF 25–75% (l/Hz)	0.32*	0.42*	0.54*	0.48*	0.38*	0.42*	0.38*	0.46*
FEF 200–1200 (l/Hz)	0.18	0.14	0.24	0.08	0.28	0.08	0.10	0.14

*Significant correlation ($P < 0.01$).

Nigeria [9]. However, this study did not include many other respiratory function tests such as FMF and FEF.

Values of FVC, FEV_1, FMF, and FEF for Nigerian children are lower than those of Caucasian children [6,9–11]. No satisfactory explanation has been offered for racial differences in lung values. Evidence favouring a genetic basis seems at least as strong as the evidence for an environmental basis, i.e. infection, nutrition, etc. [12,13]. A report by Gould [14] on 1631 healthy 'full blacks' had vital capacities markedly lower by approximately 300 cm^3 or 11% compared with whites. Negroes were shorter and had smaller chests than the whites suggesting that racial differences exist in thoracic cage, size and shape.

The differences in the values of the respiratory function tests make it mandatory that lung function measurements be made for different ethnic groups in different geographical locations. Therefore, this study has attempted to determine the range of normal values of lung function tests for children in Nigeria, so that these values serve as an index of normality for comparison with respiratory function tests in children with various respiratory disorders.

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