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Effects of socio-demographic and nutritional status on Peak Expiratory Flow Rates of rural school children in Ilesa, Nigeria

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Abstract

Background: The Peak Expiratory Flow Rate (PEFR) measured using portable peak flow metres (PFM) is a simple, cheap, readily available and reproducible measure of lung functions, particularly in resource-poor settings.
Objective: To determine the effects of socio-demographic and nutritional factors on the PEFR of school children in rural areas of Ilesa, Nigeria.
Methods: Multi-stage sampling technique was used to select children from middle schools in rural Ilesa. Their socio-demographics, housing conditions and household cooking fuel used were obtained. Anthropometric parameters and nutritional statuses of the children were determined using the WHO reference growth chart. PEFR was measured using the mini Wright PFM. The factors influencing their PEFR were determined.
Results: A total of 250 school children aged 8 to 16 years with male-to-female ratio of 0.9:1 were studied. The mean (SD) age was 12.5 (1.5) years. Over 80.0% used unclean fuel for household cooking and one-half lived in overcrowded homes. The prevalence of stunting, underweight and overweight was 22.8%, 30.8% and 3.2% respectively. The mean ± SD PEFR was 248 ± 58.6 L/min which correlated positively with the weight, height, Body Mass Index and Body Surface Area. The mean PEFR was significantly lower among children exposed to unclean fuels (245.4 ± 59.7L/min vs. 292.0 ± 59.4L/min; p = 0.02), stunted males (220.6 ± 44.9L/min vs. 264.1 ± 62.9L/min; p = 0.009) and underweight females (213.2 ± 37.8L/min vs. 247.5 ± 62.6L/min; p < 0.001).
Conclusion: Undernutrition and exposure to noxious substances from unclean household cooking fuels adversely affected the PEFR of rural school children. Early detection and prompt treatment of undernutrition and avoidance of noxious substances from unclean fuels may ensure better lung health among the children in rural areas.

Key words: Lung functions, Peak Expiratory Flow Rate, Rural, School children, Unclean fuel, Undernutrition

Introduction

Lung function assessment in children, like in adults, is useful in making diagnosis of lung health disorders, monitoring and rehabilitation as well as for epidemiological surveys. [1] The assessment of lung functions in children may involve the use of a simple device such as the peak flow meter (PFM), more complex office spirometry, sophisticated body plethysmography and gas dilution methods required for measuring residual volumes and total lung capacity. [1-3] The PFM is a portable, relatively affordable device used to measure the maximal expiratory flow rate in litres/minute sustained for about 10ms.[4] The easy availability and portability coupled with the reproducibility of PFM readings, makes it a very useful device for assessing lung functions in resource-limited settings. [4-5] However, many factors have been found to affect the readings of the PFM; these factors include the sex, age, body size, nutritional status and environmental factors. [5-7]

Malnutrition is a major predisposing factor for lung infections in children, among other effects. [8] Undernutrition is known to be highly prevalent among poor rural children with limited access to quality food and health care services. [9] Undernutrition may also have effects on lung growth as animal model studies have reported profound lung underdevelopment in animal foetuses who suffered from perinatal nutritional deficiency. [10-11] As the growth of the lungs continues through postnatal life, it is hypothesised that childhood undernutrition may also affect childhood lung growth and development and by extension, their lung capacities and flow rates.

Various parameters for assessing the nutritional status of children have been reported to vary widely in lung functions. [12-14] Majority of these reports were obtained from studies carried out outside Nigeria. In addition, there is a paucity of information about the effects of exposure to air pollutants, particularly from cooking fuels and socio-demographic parameters on the PEFR of children in rural parts of Nigeria. Therefore, this study was designed to determine the effects of socio-demographic factors, including housing, types of cooking fuel, exposure to biomass fuel and nutritional status on the PEFR of school children in rural parts of Ilesa, south-west Nigeria.

Methods

Study design and location

This was a school population-based, cross-sectional study. This study was conducted in two middle schools in rural parts of Ilesa West Local Government Area (LGA), south-west Nigeria. Ilesa (with two LGAs- West and East) is situated on latitude 7°35'N of the equator and longitude 4°51'E of the meridian and is the largest town in Ijesaland. [15] Ilesa is a semi-urban community with adjoining rural settlements and a mixture of individuals across the social classes. Children from the rural settlements attend public schools with limited access to health care and social amenities. The rural dwellers in Ilesa are mainly peasant farmers and petty traders. [15]

Sample selection

Multistage sampling method was used to select the study participants as follows: Ilesa West LGA was chosen by simple random method out of the two LGA. Ilesa west LGA had 11 public schools and 13 private schools. [16] Four of the 11 public schools were located in the rural parts of the LGA. Two schools were randomly selected out of the four rural public schools. These schools were located in the Mukoro rural community of the LGA. Each of the two selected middle schools had five arms of classes (Primary V to Junior Secondary III) and each arm had only one stream with about 30-35 students. Seven classes were randomly selected from the total of 10 classes in the two selected schools. Thereafter, the children in the selected classes were recruited till the required sample size was achieved for the study.

The inclusion criteria for this study included apparently healthy children who were able to follow instructions and satisfactorily use a mini Wright PFM. Children with asthma or other respiratory disorders, those with thoracic cage abnormalities and smokers were excluded from the study.

Sample size determination

The minimum sample size for this study was estimated using the open Epi sample size software. [17] Based on the following assumptions: using 5% significance level and 80% study power, and mean PEFR difference between well-nourished and underweight school children of 157.8L/min (obtained from the study of Suganya and Philominal [18]) and standard deviations from the mean PEFR of well-nourished and underweight children (48 and 49.2L/min respectively [18]). Using the listed parameters, the open Epi sample size (software) calculator provided a minimum sample size of 235. However, 250 school children who met the selection criteria for the study were recruited.

Ethical considerations

Institutional ethical approval was obtained from the Institute of Public Health, Obafemi Awolowo University, Ile-Ife, Nigeria (HREC approval no IPH/OAU/12/254) while official permission was also obtained from the Local Educational Authority. The permission of the Principals and Head teachers of the schools participating in the study as well as the consents of the parents were also obtained.

Study procedure

Interviewer-administered, pre-tested data proforma was used to obtain the needed information about the sex, age, tribe and family size (including the number of children in the household) from the study participants. Overcrowding, for the purpose of this study, was defined as co-habiting of three or more other persons in the same room as the child. [19]

Parental highest educational qualification and occupation were also obtained to determine the socioeconomic status of the families using the method described by Oyedeji. [20] The type of fuel used for household cooking, heating and lighting was recorded: the presence of domestic animals and pets in the household, including the poultry were also noted.

Anthropometric parameters were measured and recorded: the body weight was measured to the nearest 0.5kg using a weighing scale [Leaidal Medical Ltd, United Kingdom (UK)] while the height measured to the nearest 0.5 cm, using a RGZ-160 stadiometer [Leaidal Medical Ltd, United Kingdom (UK)] according to standard protocols. The Body Mass Index (BMI) (in kg/m^2) was derived using the formula: (weight in kg)/(height in m)^2. The Body Surface Area (BSA in m^2) was calculated from the Mostellar formula: (weight in kg x height in cm)/ 3600. [21]

The nutritional statuses of the children were determined from their anthropometrics using the WHO Growth Reference Charts Stunting and severe stunting were defined as height for age <15th and 3rd centiles respectively .Underweight was defined as BMI <15th centile while overweight was defined as BMI >85th centile on the WHO Growth Reference Chart .[22]

The Peak Expiratory Flow Rate (PEFR) was measured using the mini Wright PFM (Clement Clarke International Ltd, Airmed House, Edinburgh Way, Harlow, Essex CM20 2TT UK) with a range of reading from 60 to 800L/min and diagnostic accuracy of ±5%. [23] The procedure was explained and demonstrated to all the children. With the children standing, they were instructed to inhale to maximum capacity (total lung capacity) then to exhale as fast as possible to residual volume through the mouthpiece into the mini Wright PFM. The PFM was horizontally held such that the fingers of the children did not obstruct the cursor of the device. [23] Each study participant had three PEFR readings and the highest value was adopted for the study. [23]

Data analysis

This was done using the Statistical Program for Social Sciences (SPSS) software Version 17.0 (SPSS Inc., Chicago 2008). Test for normality was conducted on all continuous variables using Kolmogorov-Smirnov test at p<0.05. The age, weight, height, BMI, BSA and PEFR for the male and female children were summarized using means and standard deviations (SD). Proportions and percentages were determined for categorical variables such as sex and nutritional state categories. Differences between the means ± SD of continuous variables were assessed using the Student's t test and Analysis of Variance (ANOVA) as appropriate, while the categorical variables were analysed using the Pearson's Chi-Square test and Fisher's Exact test, as appropriate. Pearson Correlation coefficients were determined for the PEFR and the anthropometrics with scattergram plots. The level of statistical significance at 95% Confidence Interval (CI) was set at P < 0.05.

Results

The socio-demographic characteristics of the subjects are highlighted in Table I. The sex distribution of the subjects was comparable with male to female ratio of 0.9:1. The ages of the children ranged between 8 and 16 years with a mean ± SD age of 12.5±1.5 years. The ages of the males and females were also comparable (12.7 ±1.5 years vs. 12.3 ± 1.4 years; t = 1.743; p = 0.083). One hundred and sixty seven (69.2%) of the children were aged 11- 13 years. (Table I)

Of the 250 study participants, 247 (98.8%) were Yorubas which is the predominant ethnic group in the study site and 148 (60.0%) belonged to the lower socioeconomic class. The mean ± SD number of children per household was 4.5±1.9 (range: 1 to 19 children per household) while 179 (71.6%) of the children had more than three children per household. About 50.0% of the study participants lived in overcrowded houses. The proportions of the male and female subjects who lived in overcrowded homes were comparable (χ^2 = 1.541; p = 0.215).

One hundred and twenty six (50.4%) had at least one household animal or poultry birds in the household. These included dogs (28; 11.2%), poultry birds (75; 30.4%), cat (1; 0.4%) and goats/sheep (22; 8.8%). Only 34 (14.4%) belonged to households where clean (electric and gas) fuels were used; about two-third of the subjects used kerosene for domestic heating/cooking while 21.6% used biomass fuels, mainly firewood.

Fifty seven (22.8%) of the children were stunted including 7 (2.8%) that were severely stunted while 77 (30.8%) and 8 (3.2%) were underweight and overweight respectively. A significantly higher proportion of the male children was stunted compared to the females (35.9% vs. 15.9%; χ^2 = 12.244; p < 0.001).

Table I: Socio-demographic characteristics and nutritional status of the male and female subjects

Characteristics	*Males n =117 (%)*	*Females n =133 (%)*	*Total (n = 250)*
Age range (in years)			
8 to < 11	11 (9.4)	12 (9.0)	23
11 to < 13	69 (59.0)	98 (73.7)	167
13-16	37 (31.6)	23 (17.3)	60
Ethnicity			
Yoruba	114 (97.4)	133 (100)	247
Igbo	1 (0.9)	0 (0.0)	1
Ebira	2 (1.7)	0 (0.0)	2
Socioeconomic class			
High	0 (0.0)	0 (0.0)	0
Middle	53 (45.3)	46 (34.6)	122
Low	64 (54.7)	87 (65.4)	148
Religion			
Christianity	106 (90.6)	124 (93.2)	230
Islam	11 (9.4)	9 (6.8)	20
Overcrowded homes			
Yes	69 (59.0)	77 (57.9)	126
No	68 (41.0)	56 (42.1)	124
No of Children in household			
>3	86 (73.5)	93 (69.9)	179
=3	31 (26.5)	40 (30.1)	71
Household animals/pets			
Yes	65 (55.6)	61 (45.9)	126
No	52 (44.4)	72 (54.1)	124
Smoker in household			
Yes	2 (1.7)	2 (1.5)	4
No	115 (98.3)	131 (98.5)	246
Household fuel			
Clean fuel	10 (8.5)	26 (19.5)	36
Unclean fuel	107 (91.5)	107 (80.5)	214
Use Biomass	28 (23.9)	26 (19.5)	54
No biomass	89 (76.1)	107 (80.5)	196
Nutritional status			
Stunted	37 (31.6)	20 (15.0)	50
Severe stunting	5 (4.3)	2 (1.5)	7
Underweight	43 (36.8)	34 (25.6)	77
Overweight	1 (0.9)	7 (5.3)	8

The anthropometric parameters are highlighted in Tables II. The weight ranged from 10.2 to 23.7kg/m^2 with a mean of 16.0 ± 2.2 kg. The mean height was 1.5 ± 0.09 m with a range of 1.2 to 1.7m.

The female children were significantly taller and heavier than their male counterparts. (Table II) The BMI ranged from 17.0 to 58.0 kg/m^2 with a mean of 34.2 ± 7.8 kg/m^2 while the mean BSA was 0.6 ± 0.1 m^2 with a range of 0.4 to 1.0m^2. The female children had higher BMI and BSA compared with the males.

The PEFR ranged between 100 and 420L/min with a mean value of 248 ± 58.6 L/min. There was no significant difference in the mean ± SD PEFR of the male and female subjects as shown in Table II.

Table III highlights the relationship between the socio-demographic parameters and PEFR.

The mean PEFR of the children differed significantly across the age groups in both sexes ($F = 3.673$; $p = 0.028$ and $F = 10.100$; $p< 0.001$ respectively). There was no significant difference in the mean PEFR of the male and female subjects (249.4 ± 60.8 vs. 245.5 ± 59.5L/min; t = 0.519, p = 0.605). Likewise, no significant difference was observed in the PEFR of the children from middle class compared with those from low social class. Male children from homes which used clean cooking fuels had significantly higher mean PEFR compared to those from homes where unclean fuels were used. [(292.0 ± 59.4) vs. (245.4 ± 59.7) L/min; t = 2.360, p = 0.020]. Other socio-demographic characteristics as related to PEFR are shown in Table III.

Stunted male children had significantly lower PEFR compared with those without stunting (t = 3.479; p = 0.009). Underweight female children also had significantly lower PEFR compared with other female children who were not underweight (t = 3.849; p< 0.001) as shown in Table III.

Correlation between the PEFR and the anthropometric parameters of the subjects are highlighted in Table IV and Figures 1 to 4. There were significant positive correlations between the PEFR and age, height, weight, BMI and BSA (p< 0.001 for each) for both sexes. However, height correlated better with PEFR among the males (r = 0.532) while the weight (r = 0.480) and BSA (r = 0.486) correlated better with PEFR among the female children than the height. (Table IV)

Discussion

In the present study, over 80 percent of the children belonged to homes where kerosene and biomass fuels were used for household cooking, lighting and heating. This observation agreed with the WHO reports that up to 90 percent of rural dwellers in low and medium income countries (LMICs), including Nigeria, depend on unclean fuels, including biomass fuels, for cooking, lighting and heating. [24, 25] Persistent exposure to noxious gases and particulate matters from the burning of these unclean fuels had been reported to predispose children to recurrent respiratory tract infections, repeated exacerbations of bronchial asthma and impaired lung health. [24, 25]

The present study observed lower mean PEFR among the children whose families used unclean fuels compared to those whose families used clean fuel. This finding was in keeping with reports by Fajola et al [26] in an interventional study in River State, Nigeria, where the introduction of improved, clean burning cooking stove for six months led to an improvement in the lung function parameters of the study participants. This implies that making clean fuels available and affordable to individuals in resource-poor household settings may improve their lung health, among other health benefits.

Undernutrition is highly prevalent in the present study as stunting and underweight were observed among 22.8% and 30.8% of the children respectively. These findings agreed with the figures of the Nigerian Demographic and Health Surveys (NDHS), [9] in which 37.0% and 29.0% of Nigerian children were reported to be stunted and underweight respectively. Undernutrition was also reported to be more prevalent in the rural than the urban regions of the country. [9] Undernutrition affects lung health, among others, with the capacity to affect lung functions. [26] In the present study, the mean PEFR of the undernourished children was significantly lower compared with their well-nourished counterparts. This observation was equally reported by Faridi et al [12] and Kaur et al [13] from India. Zaire et al [14] also reported a significant reduction in PEFR and other lung function indices among 102 Polish children with malnutrition from anorexia nervosa. This reduction in lung functions and flow rates among undernourished children compared to their well-nourished counterparts had been attributed to possible muscle wasting and reduced strength of the ventilatory muscles. [27] Diminished skeletal growth found among undernourished children may also contribute to their reduced lung capacities and flow rates. [28] This implies that combating childhood undernutrition through school-based programmes such as the school meal programmes, may have long term effects on the lung health of school children.

Overweight female children in this study had lower mean PEFR compared with the non-overweight children though the difference was not significant. This finding agreed with that of Borse et al, [7] who reported significant reduction in the PEFR of overweight male Indian medical students compared to those with normal weight. This pattern was also reported by other workers. [12, 13] The very small number of overweight children in the present study may explain the lack of statistically significant difference in their PEFR compared with their non-overweight counterparts.

Table II: Anthropometric parameters and PEFR of the male and female study participants

Anthropometric parameters	Males (n = 117)	Females (n = 133)	t-test	p-value
Weight (kg) Mean ± SD	32.6 ± 6.3	35.5 ± 8.6	2.938	0.004
Height (m) Mean ± SD	1.4 ± 0.1	1.5 ± 0.1	2.491	0.013
Body mass Index (kg/m^2) Mean ± SD	15.7 ± 1.7	16.3 ± 2.5	2.956	0.003
Body Surface area (m^2) Mean ± SD	0.6 ± 0.1	0.7 ± 0.1	2.810	0.005
PEFR (L/min) Mean ± SD	249.4 ± 60.8	245.5 ± 59.5	0.519	0.605

Table III: Socio-demographic parameters and nutritional status as related to PEFR

	Males			Females		
Variables	Mean ± SD PEFR (L/min)	t-test	p-value	Mean ± SD PEFR (L/min)	t-test	p-value
Age range (in years)						
8 to < 11	210.9 ± 52.6	3.673*	0.028	186.7 ± 53.3	10.100*	<0.001
11 to < 13	247.0 ± 52.7			245.5 ± 57.5		
13 - 16	265.3 ± 72.1			275.9 ± 48.6		
Socioeconomic class						
Middle	238.5 ± 60.9	1.781	0.077	248.2 ± 53.6	0.380	0.705
Low	258.4 ± 59.8			244.0 ± 62.6		
Religion						
Christianity	248.4 ± 62.2	0.527	0.527	246.0 ± 57.8	0.400	0.690
Islam	258.6 ± 47.5			237.8 ± 83.3		
Housing						
Overcrowding	240.9 ± 58.6	1.821	0.071	237.8 ± 61.4	1.768	0.079
No overcrowding	261.6 ± 62.5			256.3 ± 55.9		
Domestic animals						
Available	248.4 ± 65.4	0.201	0.841	235.0 ± 64.7	1.884	0.062
Not available	250.7 ± 55.3			254.3 ± 60.3		
Number of children						
> 3 per household	247.0 ± 59.4	0.716	0.475	251.0 ± 58.5	1.658	0.100
=3 per household	256.1 ± 65.4			232.5 ± 60.3		
Household fuel						
Use of biomass	237.5 ± 60.4	1.189	0.237	242.7 ± 65.0	0.263	0.793
No biomass	253.1 ± 60.8			244.4 ± 59.1		
Type of fuel						
Clean	292.0 ± 59.4	2.360	0.020	249.8 6 ± 1.7	0.415	0.679
Unclean	245.4 ± 59.7			244.4 ± 59.1		
Smoker in household						
Yes	240.0 ± 14.1	0.219	0.827	275.0 ± 70.1	0.734	0.464
No	249.6 ± 61.4			244.0 ± 59.5		
Nutritional status						
Stunting	220.6 ± 44.9	3.479	0.009	235.6 ± 37.8	0.784	0.434
No stunting	263.1 ± 62.9			247.5 ± 62.6		
Underweight	236.4 ± 56.9	1.800	0.078	213.2 ± 37.8	3.623	<0. 001
No underweight	257.0 ± 62.2			247.5 ± 62.6		
Overweight	273.8 ± 52.1	0.620	0.528	240.8 (60.2	0.200	0.839
No overweight	247.2 ± 58.9			245.5 (59.5		

* Analysis of variance (ANOVA) applied

Table IV: Correlation between anthropometric parameters and PEFR

Variables	Pearson correlation coefficient with PEFR (Males)	p-values	Pearson correlation coefficient with PEFR (Females)	p-value
Weight	0.526	<0.001	0.480	<0.001
Height	0.532	<0.001	0.411	<0.001
Body mass index	0.322	<0.001	0.456	<0.001
Body surface area	0.478	<0.001	0.486	<0.001

There was a significant positive correlation between PEFR and the age, weight, height, BMI and BSA of the subjects in agreement with previous reports. [12-14] However, there was a better correlation between the PEFR and the height of the male subjects, while the PEFR for the female subjects correlated better with weight compared to height. This relationship was also observed by Nair et al [28] among healthy adolescents in India.

Figure 1a: Scattergram of PEFR vs. weight among the male subjects

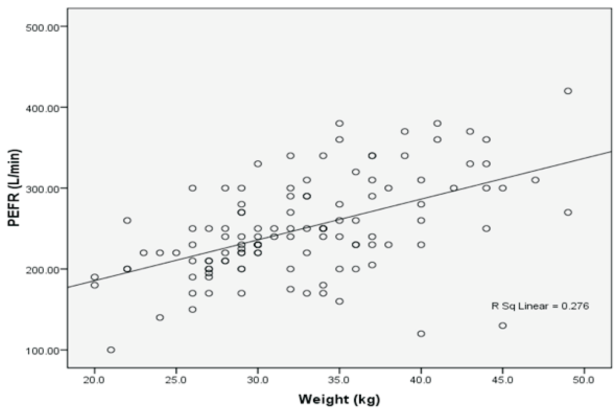


Figure 1b: Scattergram of PEFR vs. weight among the female subjects

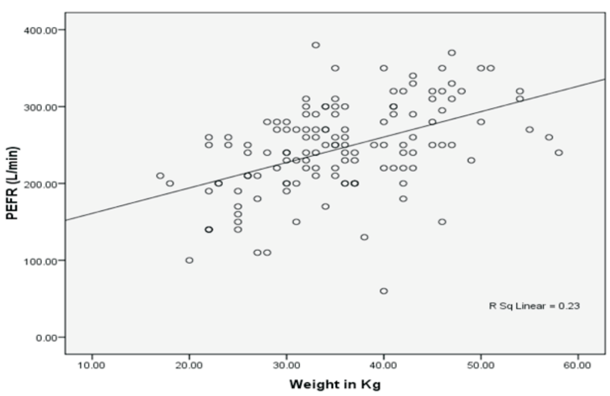


Figure 2a: Scattergram of the PEFR vs. Height among the male subjects

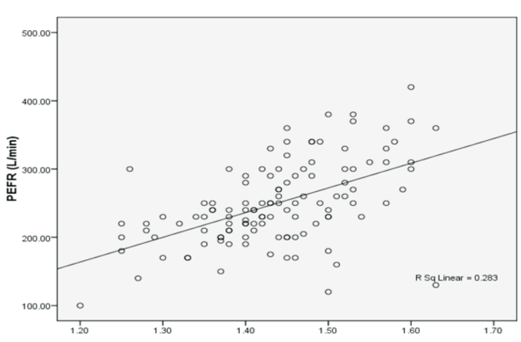


Figure 2b: Scattergram of the PEFR vs. Height among the female subjects

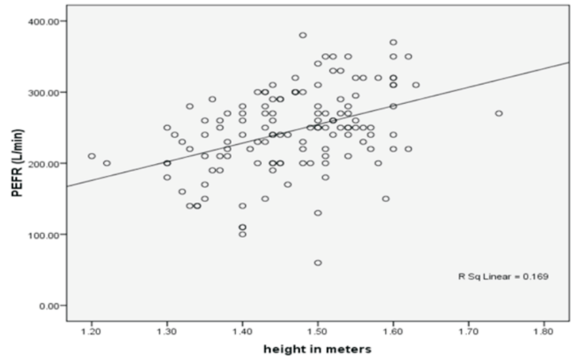


Figure 3a: Scattergram of PEFR vs. Body Mass Index among the male subjects

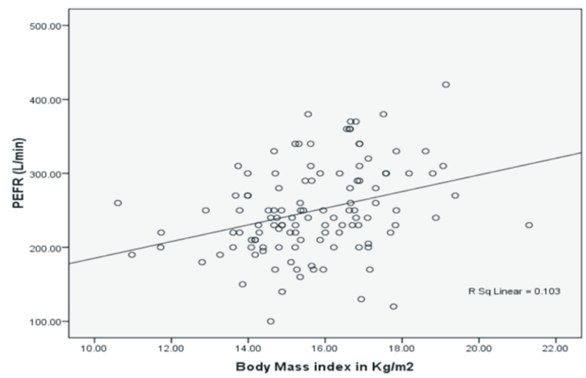


Figure 3b: Scattergram of PEFR vs. Body mass index among the female subjects

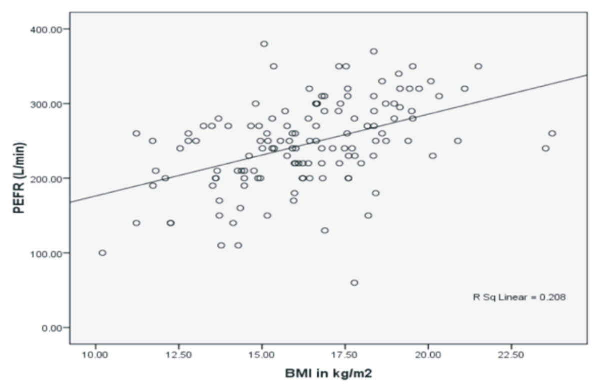


Figure 4a: Scattergram of PEFR vs. Body surface area among the male subjects

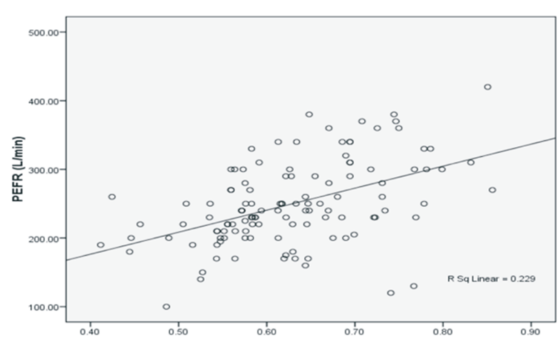
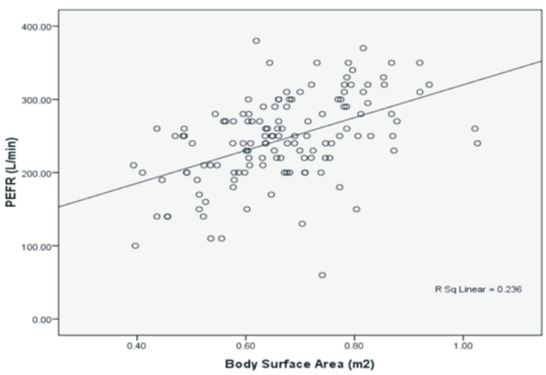


Figure 4b: Scattergram of PEFR vs. Body surface area among the female subjects



The mean PEFR was also higher among the males compared with the females in the present study, despite the fact that the females were taller and heavier. This observation agreed with the findings of other workers in similar and different settings. [12-14, 29] This may be due to variations in the physiology of the respiratory systems in boys and girls as well as the effects of reproductive hormones that set in following puberty. [6, 31] The male children have been reported to have larger lungs per unit of stature and more alveoli than female children, despite having identical alveoli per unit volume or area. [6, 31] This, coupled with the stronger respiratory muscles in males, may explain their higher mean PEFR compared to females. [28]

This study has highlighted significant reduction in the PEFR of children whose household used unclean fuels for cooking as well as the negative impact of undernutrition on the lung function parameters of school children in rural areas of Ilesa, Nigeria where access to basic infrastructures is limited. The mini Wright PFM, which was used to assess the PEFR in this study, is a reliable and relatively cheap device with reproducible readings and good correlation with FEV_1. Therefore, the PFM is ideal for use in the poor rural settings. [2, 4, 23] Its readings are easy to interpret with a range value of 60-800L/min, making it appropriate for PEFR assessment in children. [23] The assessments of PEFR in often neglected rural population of rural school children, who are lucky survivors of various diseases and infections prevalent during the under-five period, constitute strengths of this study. However, we appreciate the fact that other lung function parameters like forced vital capacity (FVC), forced expiratory volume in one second (FEV1) and Tiffeneau ratio (FEV_1/FVC), which could have given more information about the lung volumes and capacities of these children were not assessed. Likewise, the quantification of the indoor air pollutants the study participants were exposed to, through specific measurement of particulate matters ($PM_{2.5}$) and noxious gases [24, 25] was also not included in the present study. Nonetheless, this study may serve as a basis for further research on the impact of household air pollution and malnutrition on lung functions and lung health in apparently healthy school children.

Conclusion

The present study found significantly low PEFR among children in a rural setting who were exposed to indoor air pollution from the use of unclean fuels in the household as well as among stunted male and underweight female children. Provision of cleaner fuels and the prevention of undernutrition among children are recommended to ensure better lung health.

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Authors' Contributions: KBP conceptualized the study, ensured quality control, collected and analyzed the data and wrote the manuscript. KDK, OKO, OBI, MLO, OBG, MYA took part in data collection, quality control and critical review of the manuscript. All the authors approved the final version of the manuscript.
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