Peak expiratory flow rate variability in apparently healthy school children aged 10-15 years in Oredo, Nigeria

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ABSTRACT

الأهداف: دراسة تغير ذروة معدل التيار الزفيري (PEFRvar) لدى أطفال المدارس الذين يبدون بصحة جيدة في مدينة أوريدو بنيجيريا. نظراً لعدم توفر دراسة مفصلة محلية.

الطريقة: أجريت دراسة على شريحة مقطعية شملت 438 طفلاً (العمر 10-15 عاماً) الملتحقين بمدارس جونيور العامة الثانوية – نيجيريا، خلال الفترة مابين مارس 2005م وحتى نوفمبر 2005م. تم الحصول على العمر والقياسات الإنسانية للجسم، وتم تحديد تغير ذروة معدل التيار الزفيري (PEFRvar) باستعمال القيم التي تم الحصول عليها عند الساعة السادسة صباحا والساعة الثانية مساءً والساعة العاشرة مساءً على فترة 14 يوماً باستعمال مقياس متر (PEF).

النتائج: بلغت قيم تغير ذروة معدل التيار الزفيري PEFRvar mean±SD كانت (4.5±1.3%، 4.4±1.0%، 4.6±1.6%) لجميع الأطفال الذكور والإناث على التوالي. تغير ذروة معدل التيار الزفيري (PEFRvar) لدى الإناث أعلى، كان أعلى حد لـ 95%–CI 7.1% و6.4% و7.8% لجميع الأطفال الذكور والإناث. أظهر تغير ذروة معدل التيار الزفيري (PEFRvar) علاقة عكسية مع الطول، العمر، والوزن. تم تحويل اعتدال نكوص ذروة معدل التيار الزفيري (PEFR) وتغير ذروة معدل التيار الزفيري (PEFRvar) من أجل العمر، الطول، والوزن.

خاتمة: بناء على الحدود العلوية لـ 95%–CI لجميع أطفال الدراسة، يوصى بتغير ذروة معدل التيار الزفيري (PEFRvar) المتقطع 7.1%، لتشخيص انسداد مجرى الهواء الملحوظ كما في الربو تحت المتابعة في مدينة أوريدو والمناطق الأخرى التي تشترك في الخصائص الاجتماعية، التناسلية، والبدنية المشابهة.

Objectives: To study the peak expiratory flow rate variability (PEFRVar) in apparently healthy school children in Oredo, Nigeria.

Methods: We carried out a cross-sectional study of 438 subjects (10-15 years), attending the public junior secondary schools, between March and November 2005. The study took place in the Oredo Local Government Area. The age and anthropometry were taken and PEFRVar was determined using values obtained at 6 AM, 2 PM, and 10 PM over a 14-day period, using a mini-Wright peak expiratory flow meter.

Results: Peak expiratory flow rate variability (mean±SD) was 4.5±1.3% for all subjects (4.4±1.0% for males, and 4.6±1.6% for females). Females had higher PEFRVar. The upper limits of 95% CI were 7.1% for all subjects (6.4% for males, and 7.8% for females). The PEFRVar showed an inverse relationship with height, age, and weight. Regression equations for PEFR and PEFRVar were derived for age, height, and weight.

Conclusion: Based on upper limit of 95% CI for all subjects, a PEFRVar cut-off of 7.1% is recommended for diagnosis of significant airway obstruction as in asthma in the age bracket under review in Oredo and perhaps other areas, sharing similar geo-physical and social characteristics.

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The peak expiratory flow rate (PEFR) is the maximum flow rate, which can be achieved by forced expiratory effort following maximal inspiration. The maximum flow is sustained for a period of between 10 and 90 milliseconds, but commonly 10 milliseconds.[1] The PEFR could be measured with the mini-Wright peak flow meter,[2] which has a spring-loaded vane that is deflected by the air stream produced by the subject's forceful expiration. Values for PEFR, expressed in liters per minute, are now well established using this instrument.[3] It has provided pulmonologists and epidemiologists in respiratory disease research with an instrument that is suitable for use in children, especially those with asthma, where it helps in detecting and classifying the severity of lung-function abnormalities.[3,4] Absolute PEFR values are widely used by clinicians in the diagnosis and monitoring of response to therapy in children with obstructive airway diseases, especially asthma.[5,6] Several studies on PEFR values have been carried out on various populations to establish reference values.[3,7] The reference values are however dependent on the socio-demographic and anthropometric characteristics of the population studied.[3,4] The shortcomings associated with spot PEFR readings are however obviated by the use of PEFR variability (PEFRVar), which has been shown to be superior to absolute PEFR values in the diagnosis and management of asthma, especially occult cases.[8,9] It may be necessary to express PEFRVar in quantitative terms.[8,10,11] Several indices have been employed in this regard. While some studies have used, the amplitude of a consignor curve fitted to the PEFR readings, others used simpler indices such as the difference between 2 lowest PEFR values as a percentage of the daily mean.[12] Peak expiratory flow rate variability correlates strongly with some anthropometric parameters[10,13] making it possible to evolve predictive equations that could be useful in epidemiological surveys. However, data on PEFRVar are scanty in Nigeria.[13] This work, therefore, is designed to examine the PEFRVar in a cohort of apparently healthy children aged 10-15 years in Oredo LGA of Edo State, Nigeria.

Methods. The study was cross-sectional, conducted between March and November 2005. It was carried out in Oredo Local Government Area (LGA), one of the 18 LGAs in Edo State, Nigeria. The estimated population of those aged 10-15 years is 85,342. It has 2 seasons, the wet and the dry seasons. There were 32 public secondary schools in the LGA. Out of this number, 23 had junior secondary schools. Only public secondary schools were used for this study because the population structure would best reflect the socio economic strata of the community. Study subjects were drawn from 22 urban schools with facilities for junior secondary education. The age bracket of 10-15 years was chosen as children in this age range would comply better with rules and instructions for 2 weeks continuous home measurements of PEFR. Included in the study were apparently healthy school children (aged 10-15 years) who gave consent and whose parents also gave written consent to participate in the study. Exclusion criteria were children with overt mental sub-normality, evidence(s) of cardiac/respiratory diseases and sickle cell anemia. Other children whose parents declined consent, or were known asthmatics or had chest deformities. Those who are known smokers or malnourished or had access to bronchodilators were also excluded. These factors have the potentials of interfering with results of the readings. The final sample size was set to accommodate a non-response rate or attrition rate of 15%. Thus, a minimum number of 460 subjects were recruited for the study. Subjects were selected from 7 of the 22 urban public secondary schools (or 30% of Junior Secondary schools in the council). Subjects were proportionately recruited from the 7 selected schools, based on the population of students in each school. Subjects were proportionately chosen from each age cohort using a sampling ratio to carry out the number to be chosen from that class, with the first randomly picked. The weight of each subject was measured using a well-calibrated bathroom weighing scale (Hanson Ireland, Model 89 C1). The height was measured using a standiometer, well calibrated, and measuring up to 2 meters with a sensitivity of 1 mm. Approvals for the study were obtained from the Edo State Ministry of Education and the University of Benin Teaching Hospital (UBTH) Ethical Committees. Those selected subjects were thoroughly examined with the aim of identifying evidence(s) of cardiac, respiratory and other systemic illnesses following which, findings were entered into a proforma. The height was measured using the technique described by Michael Parkin and Paget Stanfield (strictly while standing) 3 times a day namely at 6am (on wakening), on return from school in the afternoon (2 pm) and at 10 pm (bedtime). The PEFR measurement was carried out in line with the Global Initiative for Asthma (GINA) guidelines.[14] Each subject took 3 measurements with one-minute rest in between the readings. The best of the 3 readings was taken as the PEFR for the time period. Recordings for the first 3 days were ignored as they were likely to be sub-optimal. Thereafter, readings were obtained for 21 consecutive days (out of which 14 completed days were selected). All completed PEFR recordings were subsequently analyzed. Also, the data from questionnaires were analyzed and the subjects stratified according to parental socio-economic classes. All collected data were entered into Microsoft Excel and crosschecked for accuracy. The data were sorted based on socio-demographic factors. The means and standard deviations for PEFRVar and other numeric variables were calculated. The data were then transported unto SPSS 11.0 for more intricate calculations/analysis. Graph Pad Instat, which reports exact p-values, was used for the inferential analysis. P-values of <0.05 were interpreted as significant. The formulas that we developed were also appropriate. Following the determination of PEFRVar and the upper limit of 95% confidence interval for all subjects of 7.1%, 7 subjects were found to have above the recommended cut-off value for the PEFRVar. These subjects were identified and were all referred to the asthma clinic at University of Benin Teaching Hospital, Benin City, Edo State, Nigeria, for follow-up.

Results. Only complete data available for 438 (95.2%) subjects were subsequently analyzed. Of these, 201 (45.9%) were males and 237 (54.1%) females with a male to female ratio of 1:1.2. The distribution of subjects in the various age cohorts for both males and females is summarized in **Table 1**. The table reveals that there were more females than males in all the age cohorts except the 10-year age cohort. The mean age, weight and height for subjects was shown in **Table 2**. Generally, the females had a comparable weight with their male counterparts. The result of PEFRVar for study subjects is shown in **Table 3**. The gender difference in the mean PEFRVar was not statistically significant (p=0.112). **Table 4** shows the relationships between PEFRVar and the variables of age, height, and weight. Furthermore, PEFRVar increased with improving family socio-economic status and this relationship between PEFRVar and family socio-economic status was also statistically significant (p=0.01). From graphs of PEFRVar plotted against weight, height, and age, predictive equations were developed (**Table 5**). Strong negative correlations existed between PEFRVar and age (r = -0.444, p=0.01); height (r = -0.379, p=0.01) and weight (r = -0.390, p=0.01). However, age had the strongest correlation with PEFRVar. The predicted values (for randomly selected age and weight were comparable with those observed, as shown in **Table 6**. Age in comparison to other variables of height and weight had higher predictive value for PEFRVar.

Table 1 - Age and gender distribution of subjects.

Age (years)	Male	Female	Total
10	37	32	69
11	37	44	81
12	37	39	76
13	40	41	81
14	28	41	69
15	22	40	62
Total	**201**	**237**	**438**

Discussion. In this study, both males and females had a comparable PEFRVar. This finding agrees with those of other workers in Nigeria and outside Africa.[10,13-15] The mean PEFRVar in this study was generally lower than values reported in previous studies.[12,16] Oviawe[13] used the age cohort of 5-15 years and obtained a mean PEFRVar of 9.2%. It is not certain why higher values should have been obtained from the latter study, but a small sample size could have paved way for over representation of younger individuals known to display higher variability in PEFR, among the cohorts used. In the current study, relationships exist between PEFRVar and age, weight and height. Indirect relationships exist between PEFRVar and age, weight and height. Variability declined with increasing age. It is observed that older children had lower PEFRVar. Similar relationships as observed between age and PEFRVar were also documented for weight and height. Similar trends had been noted by other workers.[17] Although no reason has been adduced for this by previous workers, the improvement with age, in the

Table 2 - Anthropometric characteristics of subjects studied.

Variables	All subjects		Male		Female		t test	*P*-value
	Mean	Range	Mean	Range	Mean	Range		
Age (years)	12.4 ± 1.7	10 - 15	12.3 ± 1.6	10 - 15	12.6 ± 1.7	10 - 15	1.828	0.0683
Height (cm)	154.3 ± 10.6	133 - 180	152.9 ± 11.5	133 - 180	155.5 ± 9.6	136 - 177	2.579	0.0102
Weight (kg)	45.5 ± 10.8	27 - 80	44.6 ± 11.1	27 - 80	46.3 ± 10.5	29 - 80	1.645	0.1007

Table 3 - Peak expiratory flow rate variability (PEFR) in study subjects.

Variables	Subjects (n)	Mean PEFR variability (%)	Range	95% CI of variability
All subjects	438	4.5 ± 1.3	2.53 - 8.518	1.9 - 7.1
Males*	201	4.4 ± 1.0	2.55 - 8.054	2.4 - 6.4
Females†	237	4.6 ± 1.6	2.53 - 8.518	1.4 - 7.0

Male versus females, t = 1.592, p = 0.112, CI - Confidence Interval

Table 4 - Peak expiratory flow rate variability ($PEFR_{Var}$) according to anthropometric variables (n=438).

Variable	Subjects (n)	$PEFR_{Var}$ (%) (Mean ± SD)	P-value
Gender			0.112
Male	201	4.4 ± 1.0	
Female	237	4.6 ±1.6	
Age (years)			<0.001
10	69	4.9 ± 0.9	
11	81	4.9 ± 1.6	
12	76	4.7 ± 1.0	
13	81	4.2 ± 0.9	
14	69	4.3 ± 1.7	
15	62	3.8 ± 1.0	
Height (cm)			<0.0001
130-145	102	5.1 ± 1.5	
146-161	230	4.5 ± 0.9	
>162	106	3.8 ± 1.5	
Weight (kg)			<0.0001
25-40	173	4.9 ± 1.4	
41-56	190	4.4 ± 0.9	
>57	75	3.8 ± 1.6	

$PEFR_{var}$ - Peak expiratory flow rate variability

Table 5 - Predictive equations for peak expiratory flow rate variability ($PEFR_{Var}$)

Variable_ PEFRvar	Predictive equation	r-value
Height	$0.0001 \times height^2 - 0.0673 \times height + 11.84$*	0.986
Weight	$0.0003 \times weight^2 + 0.006 \times weight + 5.0768$*	0.971
Age	$-0.0232 \times age^2 + 0.3575 \times age + 3.6929$*	0.989

*Age is in years, weight is in kilograms, height is in centimeter. The equations were computer generated.

Table 6 - Comparison of observed and predicted peak expiratory flow rate (PEFR) and variability.

Variable	Observed PEFR variability (%)	Predicted PEFR variability (%)
Age (years)		
10	4.9	4.95
11	4.9	4.82
12	4.7	4.64
13	4.2	4.42
14	4.3	4.15
15	3.8	3.84
Weight (kg)		
30	4.78	4.99
40	4.70	4.84
50	4.28	4.63
60	4.10	4.36
70	4.24	4.03
Height (cm)		
140	5.37	4.38
150	4.75	4.00
160	4.50	3.63
170	3.88	3.29
180	2.50	2.97

maturation, and hardening of tracheal cartilage (thus making it less complaint) may account for a reduction in the magnitude of variability observed in the airway of older children and young adults. However, the PEFRVar was shown to be higher among children of the affluent; namely, the high socio-economic class, than in the lower socio-economic class. The reason for this trend is not certain. This finding is at variance with those of other workers who did not demonstrate any relationship between PEFRVar and socio-economic class of subjects.[10,13] Certainly knowledge of an individual's PEFRVar and its eventual disclosure would aid in diagnosis and subsequent follow up of asthma. This would be particularly valid for the child with minimal features. We have based our reference values on a sample size of approximately 400. Perhaps a larger sample size would have been better. This could be a limitation to the study.

In conclusion, age, weight and height are good correlates of PEFRVar in school-age children in Benin city. Beyond the upper limit of 95% CI for PEFRVar of 7.1%, asthma may be suspected. Besides, inverse relationships existed between PEFRVar and age, weight and height. Since age, height, and weight demonstrated good correlation with PEFRVar any of these anthropometric indices could be used as basis for predicting PEFR in children aged 10-15 years in Benin City. Height or weight could be used where there are difficulties in obtaining the exact age of a child. However, weight as a variable in the equation would have the advantage of easy of recall because the simple recurring constants of 0.0003, 0.0006 and 5.0768 that can be abbreviated to 5.1.

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