Nigerian Journal of Paediatrics 2008; 35(3&4): 82-91

Pattern of Peak Expiratory Flow Rates in apparently Healthy School Children aged 10 – 15 Years in Oredo Local Government Area of Edo State

WO Osarogiagbon*, MO Ibadin**, O Oviawe**

Abstract

Osarogiagbon WO, Ibadin MO, Oviawe O. Pattern of Peak Expiratory Flow Rates in apparently Healthy School Children aged 10 - 15 Years in Oredo Local Government Area of Edo State. *Nigerian Journal of Paediatrics* **2008; 35: 82.**

Background: The peak expiratory flow rate (PEFR) is a useful screening tool in the diagnosis and subsequent monitoring of children with obstructive pulmonary diseases especially asthma. However, PEFR readings are subject to diurnal variations.
Objective: To determine the pattern of PEFR and the influence of a number of determinants on the pattern in a cohort of apparently healthy school children.
Subjects and Methods: A cross-sectional study was carried out to determine PEFR among 438 subjects, aged 10–15 years old, attending public junior secondary schools in Oredo Local government Area of Edo State, between March and November 2005. The biodata, weights and heights were recorded. The PEFR was then determined at 6am, 2pm and 10pm over a 14-day period, using a mini-Wright PEF meter.
Results: The PEFR (mean ± SD) L/min for all subjects at 6am, 2pm and 10pm were 380.4 ± 48.1, 394.9 ± 48.2 and 392.4 ± 47.8, respectively. Further analysis showed that the PEFR at 6am, 2pm and 10pm were 392.7 ± 57.0, 406. 8 ± 57.1 and 402.5 ± 56.7 in males compared with 369.8 ± 35.9, 383.7 ± 43.9 and 380.1 ± 35.7, respectively in the females. The gender difference in the mean PEFR values at 6am ($t = 5.1$, $p < 0.0001$), 2pm ($t = 4.823$, $p < 0.0001$) and at 10pm ($t = 5.021$, $p < 0.0001$) were all statistically significant. The PEFR showed a direct relationship with the age, height and weight, whereas the socioeconomic class had no obvious effect on the PEFR. Regression equations for PEFR were derived for age, height and weight.
Conclusion: The PEFR was higher in males than females at any time of the day. However, for both males and females, the PEFR was highest at 2pm and lowest at 6am. This is important in the adjustment of treatment and monitoring of asthmatic patients.

Key Words: Peak Expiratory Flow Rate, Pattern, Children

Introduction

THE Peak Expiratory Flow Rate (PEFR) is the maximum flow rate 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, for recordings to be valid.[1] The PEFR is measured with the Wright Peak Flow Meter,[2,3] which incorporates a spring loaded vane that is deflected by the air stream produced by the subject's forceful expiration.[2,3] This equipment is however unwieldy and unsuitable for field use. This shortcoming paved the way for the emergence of the mini-Wright flow meter which is of proven versatility and benefit to pulmonologists and epidemiologists in carrying out respiratory disease research in children, especially those with bronchial asthma.[3,4] Normal values for PEFR, expressed in litres per minute, are now well established using this instrument.[4-6]

PEFR is easy and relatively cheap to perform; it is also very useful in screening for diagnosis and subsequent monitoring of children with obstructive airways disease especially asthma. In addition, it is also a useful tool in the classification and determination of prognosis of obstructive pulmonary diseases.[4-6] Airway inflammation as the central theme in the patho-physiology of asthma is

University of Benin Teaching Hospital, Benin City

Department of Child Health
* Lecturer I/Consultant Paediatrician.
**Professor/Consultant Paediatrician

Correspondence: Dr. WO Osarogiagbon
E-mail: divinewilbel@yahoo.com.

now widely acknowledged.[7,8] There are however no reliable inflammatory markers, which can be applied in field studies to detect asthma. Recourse continue to be made to lung function indices as determined commonly through the use of peak flow meter.[8,9]

Spot recordings of PEFR values are widely used by clinicians in the diagnosis and monitoring of response to therapy in children with obstructive airway diseases, especially asthma.[6-9] Several studies on PEFR have been carried out to establish population reference standards.[4,5] These reference values are however dependent on the socio-demographic characteristics of the population studied.[4-6] More importantly, the PEFR values have been shown to vary with the time of the day of measurements (circadian variation).[10-12] Ranges of PEFR values have been reported by various workers in apparently healthy individuals of different age groups in various localities worldwide.[4,5,10,13-15] In these studies, direct relationship existed between PEFR and age, weight, height and surface area, while the gender also had an obvious effect on the PEFR with most of the study showing that males of all ages had higher PEFR than females.[4,5,14,15] Further more, as indicated above, a diurnal variation has been demonstrated showing that PEFR varies with different times of the day,[10,11,16,17] with most of the studies reporting highest PEFR at 2pm and lowest at 6am.[16,17] Therefore, for proper interpretation of observed PEFR values, it is important that the effects of gender, age, height, weight and diurnal variation be considered. Other variables known to influence the PEFR are standing height and ethnicity.[4,14]

The pattern of PEFR and the effect of these variables on PEFR have not been well documented in our centre, therefore the index study evaluated the influences of age, gender and the anthropometric indices (weight and height) and diurnal variation on PEFR measured among apparently healthy children aged 10–15 years.

Subjects and Methods

This was a prospective and cross-sectional study carried out among public school children aged 10–15 years in Oredo Local Government Area (LGA), Benin City, Edo State, between March and November, 2005. Oredo Local Government Area is one of the three LGAs in Benin City which is the state capital and one of the eighteen LGAs of Edo State.[18] The LGA covers an area of 262km². With a national growth rate of 2.89 percent, the current population of Oredo LGA is estimated to be about 385,505, while the estimated population of those aged 10–15 years is currently put at 85,342.[19]

Of the 32 public secondary schools in the LGA,[20] 22 had junior secondary schools from which eligible pupils were selected for the study. Only public secondary schools were used for the study as the population structure best reflects the prevalent socio-demographic and economic strata of the community. The study subjects consisting of children aged 10–15 years were selected from JSS I – III of the 22 urban schools. This age bracket was considered better able to comply with rules and instructions for two weeks home measurement of PEFR.[21] The ages of the children were determined using their last birthdays, which were obtained from the school register. Informed consent was obtained from both the children and their parents. Those excluded from this study included children with overt mental subnormality, evidence of cardiac/respiratory diseases, sickle cell anaemia, known asthmatics or those with chest deformities and those whose parents declined. Children who smoked or whose parents were smokers, malnourished children and those on treatment with bronchodilators or steroids were also excluded.

The sample size of 460 children was determined in accordance with the dictate of the formula for estimating a one-situation sample size when population proportion is greater than 10,000,[22] and an attrition rate of 15 percent was incorporated. The sample size of 460 was to be selected from the 22 urban public secondary schools. However, when dealing with a large population that cannot all be sampled, 30 percent of that population is taken as representative of the entire population and should display the statistical properties of that population.[23] Thus, 30 percent of the number of junior secondary schools in Oredo LGA was used, i.e. seven schools. Of the seven schools, and using proportionate representation of ratio for mixed: males : females of 5 : 6 : 11, two mixed schools, two all boys schools and three all girls schools were selected. The 460 students were then selected proportionately from the chosen schools based on the total number of students in the schools using multistage stratified sampling technique.[20]

To make room for adequate representation of the various age cohorts, subjects were proportionately chosen using a sampling ratio as determined for varying populations. The first in each class was however randomly chosen.

Approval for the study was obtained from Edo State Ministry of Education and the University of Benin Teaching Hospital (UBTH)'s Ethical Committee. The weights of the subjects were determined using a well-calibrated bathroom weighing scale (*Hanson, Ireland*, Model 89 C_1) and the height was measured to the nearest 0.1 cm, using a well-calibrated standiometer, measuring up to two metres. The selected subjects were educated on the procedure of serial PEFR measurement and questionnaires containing information on both parents that enabled the family socio-economic status to be determined in accordance with the recommendation of Olusanya *et al*,[24] were given to each selected student to be completed by their parents/guardians. Following this, each subject had a thorough and careful physical examination. Thereafter, each subject was given a peak flow meter and was required to blow into it at 6am, 2pm and 10pm while standing, the 2pm recordings were done at school under the supervision of one of the authors and the previously trained teachers. Recordings were made for a period of 21 days (out of which 14 completed days were selected) in accordance with the Global Initiative of Asthma Management (GINA) recommendations.[25] During each measurement, three readings were obtained and recorded, but the best reading was accepted as final recording.

Statistical analysis

All completed PEFR recordings were subsequently analysed as were the data from the questionnaires 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 PEFR and other numeric variables were calculated. Discrete variables were expressed in proportions or percentages. The data were then 'transported' on to SPSS 11.0 for more intricate calculations/analysis. *Graph Pad Instat*, which reports exact p-values, was used for the inferential analysis. The student's 't' test and Chi-square test where appropriate, were used to assess associations between the variables. P-values <0.05 were interpreted as significant. Formulae were also developed where appropriate.

Subjects with recordings that were suggestive of airway obstruction were identified and referred for follow-up to the Asthma clinic at UBTH.

Results

Data for 438 (95.2 percent) subjects were complete and were subsequently analyzed. Of these, 201 (45.9 percent) were males and 237 (54.1 percent) females giving a M:F ratio of 1:1.2. The distribution of subjects in the various age cohorts for both males and females is as shown in Table I. The mean age for all the subjects was 12.5 ± 1.7 years (range 10–15 years). The mean age for males of 12.5 ± 1.6 years was comparable to that of females of 12.6 ± 1.7 years ($p = 0.0683$). As shown in Table II, the mean height for all subjects was 154.3 ± 10.6cm (range 133–180cm). The mean height for males of 152.9 ± 11.5cm, (range 133 - 180cm) differed significantly from that obtained in females (155.5 ± 9.6cm, range 136–177cm) ($p = 0.0102$). The mean weight for all subjects was 43.5 ± 10.8kg (range 27–80kg). Males had a mean weight of 44.6 ± 11.1kg (range 27–80kg) as against 46.3 ± 10.5 for females (range 29–80kg; $p = 0.1007$).

Relationships between age, weight, height, socio-economic status and PEFR

The mean PEFR (L/min) values for all males subjects was 400.7 ± 56.9 while the mean PEFR (L/min) values for all female subjects was 377.8 ± 38.5; the mean PEFR vary significantly with gender ($p < 0.0001$), increased with increasing age, with the highest value obtained in the age cohort of 15 years. The mean PEFR varied significantly with age ($p < 0.0001$). Similarly, there were strong associations

Table I

Age and Sex Distribution of the 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

Table II

Distribution of Mean PEFR according to Anthropometric/Socioeconomic Variables

Variables	*No of Subjects*	*PEFR (L/min) (Mean ± SD)*	*p-value*
Gender			
Male	201	400.7 ± 56.9	
Female	237	377.8 ± 38.5	<0.0001
Age (years)			
10	69	343.5 ± 16.4	
11	81	358.9 ± 21.2	
12	76	371.9 ± 29.3	
13	81	397.6 ± 31.4	
14	69	429.2 ± 49.7	
15	62	438.9 ± 52.7	<0.0001
Height (cm)			
130 – 145	102	340.5 ± 13.4	
146 – 161	230	382.3 ± 28.0	
162 and above	106	447.1 ± 48.0	<0.0001
Weight (kg)			
25 – 40	173	353.0 ± 22.0	
41 – 56	190	396.1 ± 34.6	
57 and above	75	449.7 ± 55.3	<0.0001
Socioeconomic Class			
1	14	380.3 ± 44.9	
2	69	383.5 ± 40.4	
3	205	286.8 ± 44.7	
4	122	399.9 ± 60.7	
5	28	392.6 ± 56.6	0.2513

Table III

Mean PEFR Values at Various Times of the Day according to Gender

Time of Measurement	*PEFR (Mean ±SD) L/Min*		t	p-values
	Male *n = 201*	Female *n = 237*		
6am	392.7 ± 57.0	369.8 ± 35.9	5.106	<0.0001
2pm	406.8 ± 57.1	383.5 ± 43.9	4.823	<0.0001
10pm	402.5 ± 56.7	380.1 ± 35.7	5.021	<0.0001
F	6.834	3.818		
p-value	0.0012	0.0224		

Table IV

PEFR of Subjects at Various Times of the Day

Time of Day	*Number of Subjects*	*PEFR (Mean ± SD)*
6am[a]	438	380.4 ± 48.1
2pm[b]	437	394.9 ± 48.2
10pm[c]	435	390.4 ± 47.8

**t-test comparison: a vs b, p = 0.001, a vs c, p = 0.01 b vs c, p = 0.167*

Table V

Predictive Equations for PEFR

Variables	*Predictive Equation**	*r-value*
PEFR		
Age	$202.13e^{0.0523\,age}$	0.999
Weight	$0.029wt^2 + 2.195wt + 275.65$	0.999
Height	$0.0524ht^2 - 12.613ht + 1069.3$	0.999

**Computer generated e = Exponential wt = Weight ht = Height*

Table VI

Comparison of Observed and Predicted PEFR

Variables	*Observed PEFR (L/min)*	*Predicted PEFR (L/min)*
(Years)		
10	343.5	341.01
11	358.9	359.32
12	371.9	378.61
13	397.6	398.94
14	429.2	420.36
15	438.9	442.93
Weight (kg)		
30	337.20	367.60
40	370.37	409.85
50	412.87	457.90
60	425.82	511.75
70	480.95	571.40
Height (cm)		
140	331.96	330.52
150	367.16	356.35
160	408.13	392.66
170	443.45	439.45
180	536.43	496.72

between PEFR and height ($p<0.0001$) on one hand and with weight ($p<0.0001$) on the other (Table II). For socio-economic class also shown in Table II, there was a direct relationship between the PEFR and the social status with socio-economic class V having the highest mean PEFR value in comparison with other classes, but this variation of PEFR with the socio-economic class was not statistically significant ($p=0.2513$).

Relationships between gender, time of measurement and PEFR

As shown in Table III, the mean PEFR (L/min) obtained for males at 6am, 2pm and 10pm were 392.7 ± 57.0, 406.8 ± 57.1 and 402.5 ± 56.7, respectively as against 369.8 ± 35.9, 383.7 ± 43.9 and 380.1 ± 35.7, for females. The gender difference in the mean PEFR values at 6am ($t=5.1$, $p<0.0001$); 2pm ($t=4.823$, $p<0.0001$) and at 10pm ($t=5.021$, $p<0.0001$) were all significant.

Circadian rhythm of PEFR

For either sex, the differences between the mean PEFR values at 6am and at 2pm, were highly significant (males: $p = 0.001$; female: $p = 0.001$). Similarly, those between 2pm and 10pm in the two sexes were also significant (male: $p = 0.01$; female: $p = 0.01$) (Table IV). A positive correlation existed between the 6am and the 2pm PEFR values. Based on this, a regression equation was developed i.e. $y = 0.9867x - 9.0839$, ($r = 0.984$). The equation enables the values of PEFR for a particular time of interest to be deduced from values at other times in the same subject. From graphs plotted against weight, height and age, predictive equations were developed (Table V). Age had the strongest correlation with PEFR. When predicted values were generated based on these equations, they compared favourably with observed values (Table VI).

Of the 438 subjects with complete data, 332 (75.9 percent) had discernable pattern in PEFR recordings, of which 316 (72.2 percent) had the lowest PEFR values (trough or nadir) at 6am which was followed by highest value of PEFR (achrophase) at 2pm and then a slight fall at 10pm (Figure 1A). The remaining 16 (3.7 percent) of the subjects had lowest PEFR (trough or nadir) at 6am, highest (achrophase) at 2pm, and then the FEFR plateaued at 10pm (Figure 1B). Both patterns displayed a "dip" in the mornings, whereas the former had another dip in the evening

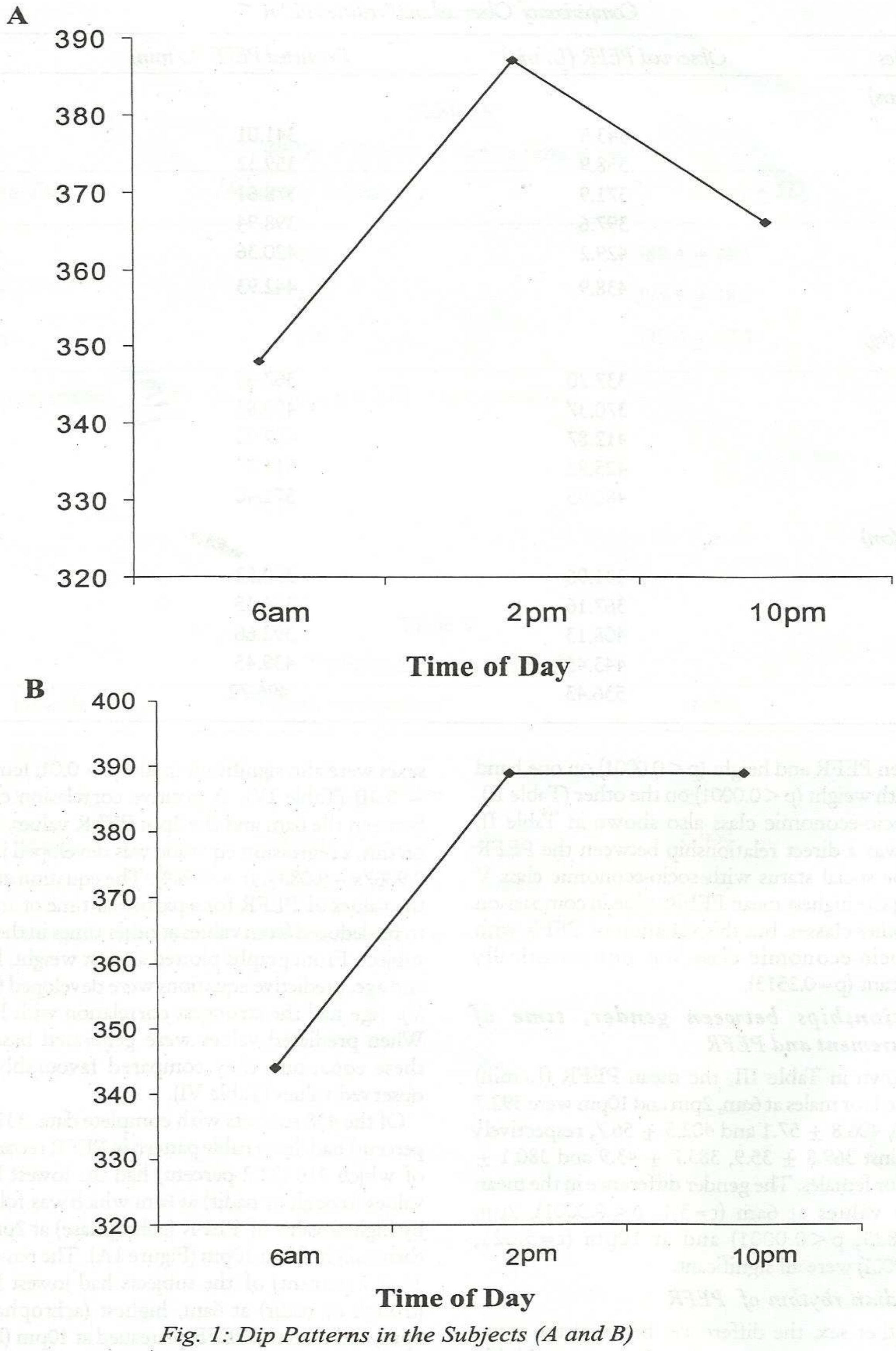

Fig. 1: Dip Patterns in the Subjects (A and B)

(although less than the morning dip), the latter plateaued out in the evening.

When all subjects were considered (both those with discernable and non-discernable patterns), a total of 388 (88.8 percent) subjects had lowest mean PEFR at 6am. Three (0.68 percent) had lowest PEFR values at 10pm, 47 (10.70 percent) had lowest at both 6am and 10pm. None had lowest values at 2pm. Highest values were seen at 2pm in 403 (92 percent), at 10pm in 35 (8.0 percent), while none had highest values at 6am.

Discussion

The "dip" patterns in PEFR as seen in the study with lowest values of PEFR at 6am then a peak at 2pm and a slight fall or plateau at 10pm, have also been reported previously by Oviawe in Benin City,[16] and workers from other countries.[12,21,26] A similar pattern of PEFR rhythmicity was also reported by Aggarwal and co-workers in India on apparently healthy young adults aged 20–40 years.[27] They reported a discernable pattern or rhythmicity in 74.6 percent of their subjects, close to the 75.9 percent seen in the present study. The differences between the 6am and either the 2pm or 10pm values were statistically significant, in contra-distinction to what obtained between the 2pm and 10pm values. This finding is similar to those noted by Oviawe in Benin[16] and other workers outside Nigeria.[12,21] This normal circadian variation in the airway calibre of normal subjects has been ascribed to several endogenous factors such as circulating levels of histamine, adrenaline, cortisol and vagal activities.[28,29] The circulating levels of these substances have been reported to follow a circadian pattern with highest levels at 2pm and lowest at 6am. Increased levels of these substances in circulation, lead to an increase in the calibre of the airway (bronchodilation) and vice versa.[28,29] In the study by Oviawe,[16] it was demonstrated that this pattern seen in healthy subjects was similar to that also seen in asthmatics, although asthmatics tended to have greater amplitude of variation, as also noted in reports from other countries.[12,30] This observation may have some relevance in the management of asthmatics. Its importance could be mainly in terms of monitoring and adjustment of therapy. From the present study, it is obvious that most of the subjects had lowest values of PEFR at 6am, and almost all subjects had highest PEFR at 2pm. Values of PEFR obtained at 10pm did not vary significantly from those obtained at 2pm. Therefore, it is opined that the magnitude of daily variation in PEFR can be adequately displayed by two daily measurements carried out at 6am and 2pm. Regarding clinical application, this could suggest that optimal spot PEFR measurements should be done in the afternoon when the PEFR is likely to be optimum. However, if there is need for the PEFR to be evaluated at any other time of the day, a predictive equation could be of value in deriving values that would otherwise have been obtained at 2pm (which produces optimal values), as predictive equations exist between values obtained at other times and 2pm value.

Despite the fact that females were heavier and taller (age for age), when compared with males, their mean PEFR was significantly lower for all the times. Although no clear-cut reason has been adduced for this gender variation seen both in this and in previous studies,[4,5,13,15,31] the enhanced muscular endowment in males may mean that they have stronger and more developed respiratory and anterior abdominal wall muscles. This may translate to more forceful and efficient expiratory effort in males than in females. Furthermore, females were also likely to have smaller airway calibre when compared with males of the same weight and height.

There was a significant difference in heights between both sexes. This may be due to the fact that the "pubertal growth spurt" which occurs in children at the onset of puberty, takes place much earlier in females than in males.[4] Within the confines of the age bracket studied, females were more likely to have achieved this growth spurt than their male counterparts.

In the current study, direct relationships existed between PEFR and each of age, weight and height. The observation that older children had higher mean PEFR has also been reported by other workers.[4,5,15] Although no reason has been adduced for this observation by previous workers, the improvement with age in the maturation and hardening of the tracheal cartilage (thus making it less compliant) may account for a reduction in the magnitude of variability observed in the airway of older children and young adults. PEFR values were higher in children from low socio-economic background in comparison with those from affluent families – a finding that is at variance with those of other workers who observed no relationship between the two variables. The reason for this observed trend is however not readily discernible.

In conclusion, discernible rhythms in PEFR existed among apparently healthy children aged 10–15 years in Benin City. Besides, associations also existed between age, weight, height and PEFR. Peak spot PEFR values are most likely to be obtained at 2pm among such children. Where readings are impracticable at this time, suitable equations exist that could enable their derivations from values obtained at other times.

Limitations of the study

(a) Reliance on subjects to comply with the instructions on how to use the peak flow meter, notwithstanding the close monitoring by the researchers and school teacher was a limitation. Directly supervised use of peak flow meter probably would have improved the outcome of the study.

(b) The use of mini-Wright rather than the standard Wrights was also a limitation. However, previous studies have demonstrated a correlation between the values obtained by both instruments.

Acknowledgements

The contributions of individuals and institutions to the completion of this project are deeply appreciated. Such include residents in the department of child health, UBTH, the study subjects, their parents/ guardians and teachers in the various secondary schools used for this study. Others include the managements of Edo State Ministry of Education, Oredo Local Government Council and GlaxoSmithKline Plc.

References

1. Quanjer PH, Labowitz MD, Gregg I, Miller MR, Pedersen OF. Peak expiratory flow: conclusions and recommendations of a working party of the European Respiratory Society. *Eur Respir J* 1997; 10 Suppl 24: S2-8.
2. McNaughton JP. Portable peak flow meters. *Eur Respir J* Suppl 1997; 24: S26-8.
3. Perks WH, Tams IP, Thompson DA, Prowse K. An evaluation of the mini – Wright peak flow meter. *Thorax* 1979; 34:79-81.
4. Aderele WI, Oduwole O. Peak flow rate in healthy school children. *Nig J Paediatr* 1983, 10: 45-55.
5. Okoromah CN, Oviawe O. Peak expiratory flow rate in children living in Enugu urban area, Nigeria. *Nig Qt J Hosp Med* 2000; 10: 171-4.
6. Lebowitz MD. The use of peak expiratory flow rate measurements in respiratory disease. *Pediatr Pulmonol* 1991; 11:166–74.
7. Martin RJ, Cicutto LC, Smith HR, Ballard RD, Szefler SJ. Airway inflammation, nocturnal asthma. *Am Rev Respir Dis* 1991; 143:351-7.
8. Mark B, Donald YM. Allergic disorders. In: William WH, Anthony RH, Myron JL, Judith MS, eds. Current Pediatric Diagnosis and Treatment. London: Lange Medical Books/McGraw – Hill, Ltd, 2001: 939–43.
9. Cockroft DW, Hargreave FE. Airway hyperresponsiveness: relevance of random population data to clinical usefulness. *Am Rev Resp Dis* 1990; 142:497-500.
10. Frischer T, Meinert R, Urbanek R, Kuehr J. Variability of peak expiratory flow rate in children: short and long term reproducibility. *Thorax* 1995; 50:35–9.
11. Lebowitz MD, Krzyzanowski M, Quackenboss JJ, O'Rourke MK. Diurnal variation of PEFR and its use in epidemiological studies. *Eur Respir J Suppl* 1997; 24: S49-56.
12. Hetzel MR, Clark TJ. Comparison of normal and asthmatic circadian rhythms in peak expiratory flow rate. *Thorax* 1980; 35: 732–8.
13. Bjure J, Dalen G, Kjellman B. Peak expiratory flow rate: reference values for Swedish children. *Acta Paediatr Scand* 1979; 68: 605–7.
14. Jacobs DR Jr, Nelson ET, Dontas AS, *et al*. Are race and sex differences in lung function explained by frame size? The CARDIA Study. *Am Rev Respir Dis* 1992; 146: 644–9.
15. Ali MA, Vahalia KV. Some observations of peak expiratory flow rate in normal school children in northern Nigeria. *West Afr J Med* 1991; 10:141–9.
16. Oviawe O. The amplitude of variation of PEFR in normal and asthmatic children – Abstract of Proceedings of the 24th Annual Conference of the Paediatric Association of Nigeria. *Nig J Paediatr* 1993; 20:80.
17. Albertini M, Politano S, Berard E, Boutte P, Mariani R. Variation in peak expiratory flow of normal and asymptomatic asthmatic children. *Paediatr Pulmonol* 1989; 7:140–4.
18. Ward System of Oredo Local Government. Town Planning/Department Oredo LGA Benin City, 2002.
19. National Population Commission. 1991 Provisional Census Figures. Edo State Statistical Tables, 1994.
20. Directory of Public Schools and Their Population, Edo State. 2003. Published by the Planning, Research and Statistics Department, Ministry of Education, Iyaro, Benin City.
21. Perez-Padilla R, Regalado-Pineda J, Mendoza L, Rojas R, *et al*. Spirometric variability in a longitudinal study of school-aged children. *Chest* 2003; 123: 1090-5.
22. Araoye OM. Research Methodology with Statistics for Health and Social Sciences. Ilorin: Nathadex Publishers, 2003: 115-21.
23. Ogidiolu A. Productivity of Cultivated Indigenous Tropical Tree Species in rRelation to Site Characteristics in a part of Western Nigeria. PhD Thesis, Department of Geography, University of Ibadan, 1997:45.
24. Olusanya O, Okpere E, Ezimokhai M. The importance of social class in voluntary fertility

control in a developing country. *West Afr J Med* 1985, 4:205-12.

25. Global Strategy for Asthma Management and Prevention. Update from the NHLBI/WHO Workshop Report; January 1995, (Revised 2002) NIH Publication No. 02-3659.
26. Connolly CK. Diurnal rhythms in airway obstruction. *Br J Dis Chest* 1979; 73: 357-66.
27. Aggarwal, AN, Gupta D, Chaganti S, Jindal SK. Diurnal variation in peak expiratory flow in healthy young adults. *Indian J Chest Dis Allied Sci* 2000; 42: 15–9.
28. John BW. Respiratory Physiology – The Essentials. Oxford: Blackwell Scientific Publication, 1979: 1-11 & 109–10.
29. van-Alderen WM, Postma DS, Koeter GH, Knol K. Nocturnal airflow obstruction, histamine and the autonomic central nervous system in children with allergic asthma. *Thorax* 1991; 46: 366-71.