LUNG FUNCTIONS IN MALNOURISHED CHILDREN AGED FIVE TO ELEVEN YEARS

M.M.A. Faridi
Pratibha Gupta
Anupam Prakash

ABSTRACT

Lung functions including FVC, FEV_1, PEFR, $\%FEV_1/FVC$ and Empey Index were measured using P.K. Morgan's pocket spirometer on 122 children of both sexes in the age group of five to eleven years. There were 80 (65.57%) malnourished children according to the Indian Academy of Pediatrics classification. FVC and FEV, were significantly ($p<0.02$) reduced in malnourished children. FVC ($r = 0.67$, $p <0.001$), FEV_1 ($r = 6.68$, $p <0.001$) and PEFR ($r = 0.53$, $p <0.001$) showed linear relationship with body surface area in all age groups. Empey index was less than 10 in both healthy and malnourished children. Abnormal respiratory functions should be interpreted with caution in malnourished children.

Key words: *Protein energy malnutrition, Respiratory functions, Empey index.*

From the Departments of Pediatrics and Physiology, University College of Medical Sciences and Guru Tegh Bahadur Hospital, Delhi 110 095.

Reprint requests: Dr. M.M.A. Faridi, D-18, GTB Hospital Campus, Delhi 110 095.

Received for publication: May 24, 1993;
Accepted: June 15, 1994

Undernutrition leads to higher susceptibility of children to suffer from various infections and nutritional deficiencies and contributes to high rates of morbidity and mortality(l). Acute respiratory infections (ARI) in children constitute an important group of diseases with very high morbidity and deaths. The WHO initiated ARI Control Programme worldwide to effectively and timely treat ARI and improve quality survival in children(2). Literature pertaining to the respiratory status of Indian children both in health and disease is very scanty. There are, virtually, no reports available on the effect of protein energy malnutrition on respiratory functions. Non-availability of simple and sensitive equipments, non-cooperation on the part of child patient, logistic problems and indifference might have been the impediments to carry out research in this area. Thus, this study was undertaken to evaluate the effects of nutritional status on lung functions in the age group of 5-11 years.

Material and Methods

One hundred and twenty-two children, attending Pediatrics Out-patients' Department of Guru Tegh Bahadur Hospital, Delhi, in the age group of 5 to 11 years were randomly selected. They were divided into three groups of 5-7, 7-9, and 9-11 completed years. The weight (kg) and height (cm) were recorded by standard method and body surface area was calculated by Du Bois' formula(3). The nutritional assessment was done according to the Indian Academy of Pediatrics classification^); reference weight was taken to be the fiftieth percentile of the weight for the particular age from the NCHS standard(5). The children were divided into healthy and malnourished according to the Indian Academy of Pediatrics classification^). Children suffering from chest infections, bronchial asthma, heart ailments and hyperpyrexia were excluded from this study. Lung function tests, namely Forced Vital Capacity (FVC), Forced Expiratory Volume in first second (FEV_1), Peak Expiratory Flow Rate (PEFR), Percentage of FEV_1/FVC (% FEV/FVC) and Empey Index (FEV_1/PEFR(6) were calculated using P.K. Morgan's Pocket Spirometer (P.K. Morgan Pvt. Ltd., England). The procedure was demonstrated number of times to each subject individually up to our satisfaction. Three readings were taken from each subject by one of us (A.P.) and the most consistent one was noted. The data was subjected to correlation and regression analysis using SPSS package and scatterograms were prepared using Lotus 1-2-3 package on a personal computer. 'Unpaired t-test' was applied as and when necessary.

Results

There were 42 healthy and 80 malnourished children. The overall male to female ratio was 2.7:1. FVC, FEV_1 and PEFR in healthy and malnourished children are shown in *Tables I, II & III,* respectively. FVC and FEV_1 were reduced significantly

TABLE I- *Forced Vital Capacity (FVC) in Healthy and Malnourished Children*

Age (yrs)	Subjects*		FVC (L)	
	Control (n=41)	PEM (n=72)	Control x±SD	PEM x±SD
5-7	23	9	0.84 ±0.18	0.52 ±0.17*
7-9	9	28	1.10 ±0.32	$0.89±0.23^{\$}$
9-11	9	35	1.45+0.38	$1.17 ±0.31^{\$}$

* In nine subjects, FVC could not be evaluated.
+ p<0.001, $ p<0.05.

TABLE II- *One Second Forced Expiratory Volume (FEV_1) in Control and Study Group.*

Age (yrs)	Subjects*		FEV_1 (L)	
	Control (n=41)	PEM (n=72)	Control x±SD	PEM x±SD
5-7	23	9	0.80±0.17	$0.48±0.18^{+}$
7-9	9	28	1.06±0.32	$0.83±0.23^{\$}$
9-11	9	35	1.37±0.35	$1.12±0.31^{\$}$

* In nine subjects, FEV_1 could not be evaluated.
+ p <0.001, $ p <0.05.

TABLE III- *Peak Expiratory Flow Rate (PEFR) in Healthy and Malnourished Children*

Age (yrs)	Subjects		PEFR (L/min)	
	Control (n=42)	PEM (n=80)	Control x±SD	PEM x±SD
5-7	23	9	105.5±27.2	81.4±40.1
7-9	9	32	127.8±36.3	104.6±40.8
9-11	10	39	153.2±44.6	142.0±38.4

p = not significant.

($p<0.05$) among malnourished children in all age groups. Both FVC ($r = 0.22$, $p <0.02$) and FEV_1 ($r = 0.24$, $p <0.02$) showed direct linear correlation with body weight *(Figs 1&2).*

%FEV_1/FVC was not different in healthy and> malnourished children in 7-9 and 9-11 years age group *(Table IV).* Similarly, Empey Index was also not significantly different in healthy and malnourished children *(Table V).*

Height of all malnourished children was

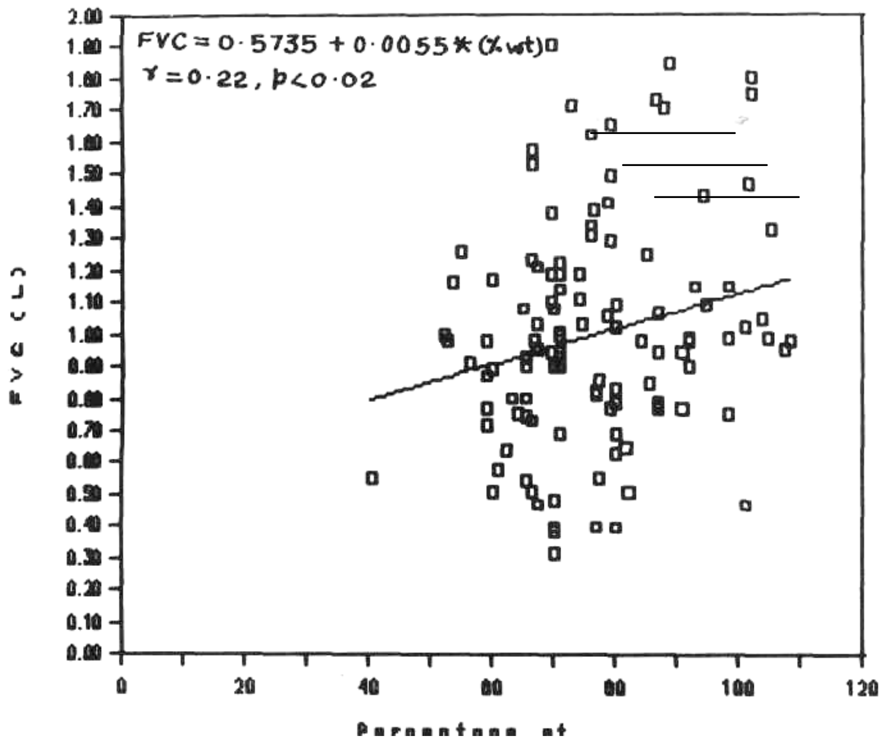

Fig. 1. *Scatterogram showing Forced Vita Capacity (FVC) in relation to percentage body weight (% wt).*

>80% of the expected height for age but the body surface area was significantly low ($p < 0.001$) in comparison to healthy children. The FVC ($r = 0.67$, $p < 0.001$), FEV_1 ($r = 0.68$, $p < 0.001$) and PEFR ($r = 0.53$, $p < 0.001$) showed direct correlation with the body surface area *(Figs. 3-5).*

Discussion

All malnourished children in our study were suffering from acute protein energy malnutrition since their height was >80% of the expected height for the age. FVC and FEVj were significantly reduced in malnourished children in all age groups. However, some of the respiratory functions like PEFR and $\%FEV_1/FVC$ were spared from ill-effects of PEM, although the values were always lower in malnourished children.

The inspiratory and expiratory capacity depends upon endurance and strength of the respiratory muscles and bony cage. The muscle is a principal protein reservoir and gets utilized during nutritional deprivation resulting in its wasting. Flabbiness, hypotonia, tenderness and stiffness of muscles are clinical manifestations of PEM in order of severity(7). The histopathological changes of PEM in skeletal muscles include

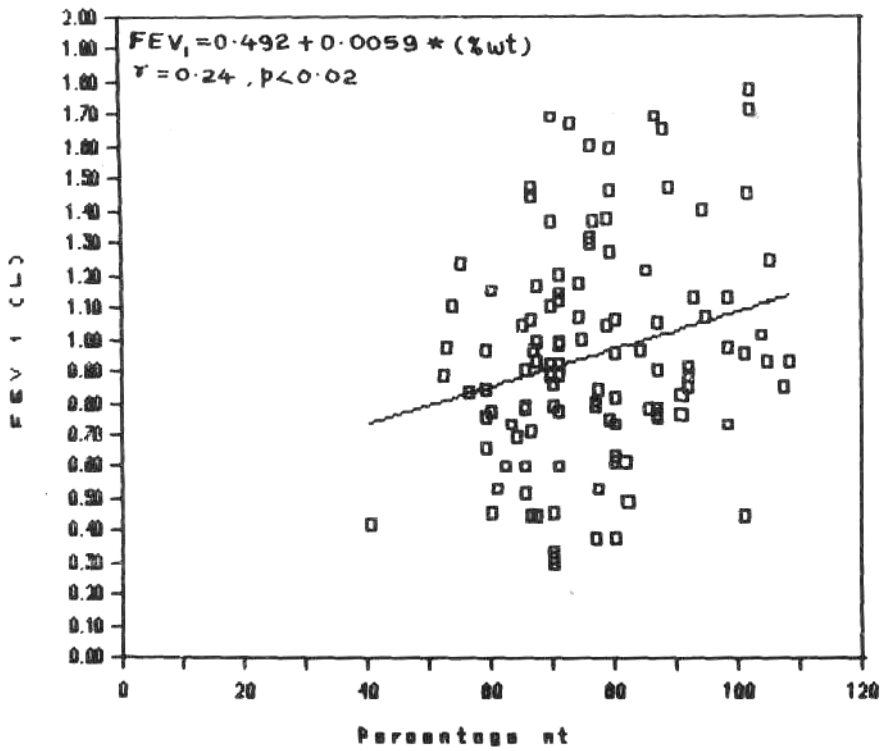

Fig. 2. Scatterogram showing relationship between one second Forced Expiratory Volume (FEV$_1$) and percentage body weight (% wt).

reduction in the number and size of muscle fibres, myotube formation, loss of cross-striations, disorganization of sub-sarcolemmal nuclei, perivascular edema and fibrous metaplasia in severe cases(7-9). Further the reduction in size and number of muscle fibres is directly related to the degree of PEM. It was, therefore, expected that respiratory functions would be affected in the presence of PEM. Indeed, FVC, *FEV_1* and PEFR were reduced in the PEM subjects in our study.

In the presence of upper airway obstruction the reduction in PEFR is greater than the reduction in FEV^IO). In contrast, with lower airway obstruction there is proportionate decrease in FEV_1 and PEFR. The Empey Index is therefore higher (>10) in upper airway obstruction and is normal (<10) in lower airway obstruction and in healthy subjects(6). Empey Index in our study was normal because both FEV_1 and PEFR decreased proportionately as a result of poor endurance and strength of respiratory muscles.

To the best of our knowledge, respiratory functions in malnourished children have not been evaluated. Not a single study

TABLE IV– *Per cent Ratio of One Second Forced Expiratory Volume and Forced Vital Capacity (%FEVI/FVC) in Healthy and Malnourished Children.*

Age (yrs)	Subjects*		%FEV_1/FVC	
	Control (n=41)	PEM (n=72)	Control x̄ ± SD	PEM x̄ ± SD
5-7	23	9	94.8±3.5	91.2±5.8$
7-9	9	28	96.4±2.7	93.2±6.2
9-11	9	35	95.0±5.9	95.0±5.5

* In nine subjects, %FEV_1/FVC could not be evaluated.

$ $p < 0.05$.

TABLE V– *Empey Index in Healthy and Malnourished Subjects.*

Age (yrs)	Subjects*		Empey Index (ml/L/min)	
	Control (n=41)	PEM (n=72)	Control x̄ ± SD	PEM x̄ ± SD
5-7	23	9	7.71±1.35	6.37±2.12+
7-9	9	28	8.47±1.95	7.97±3.02
9-11	9	35	9.64±2.25	7.98±2.24

* In nine subjects, Empey Index (ml/L/min) could not be evaluated.

\+ $p < 0.05$.

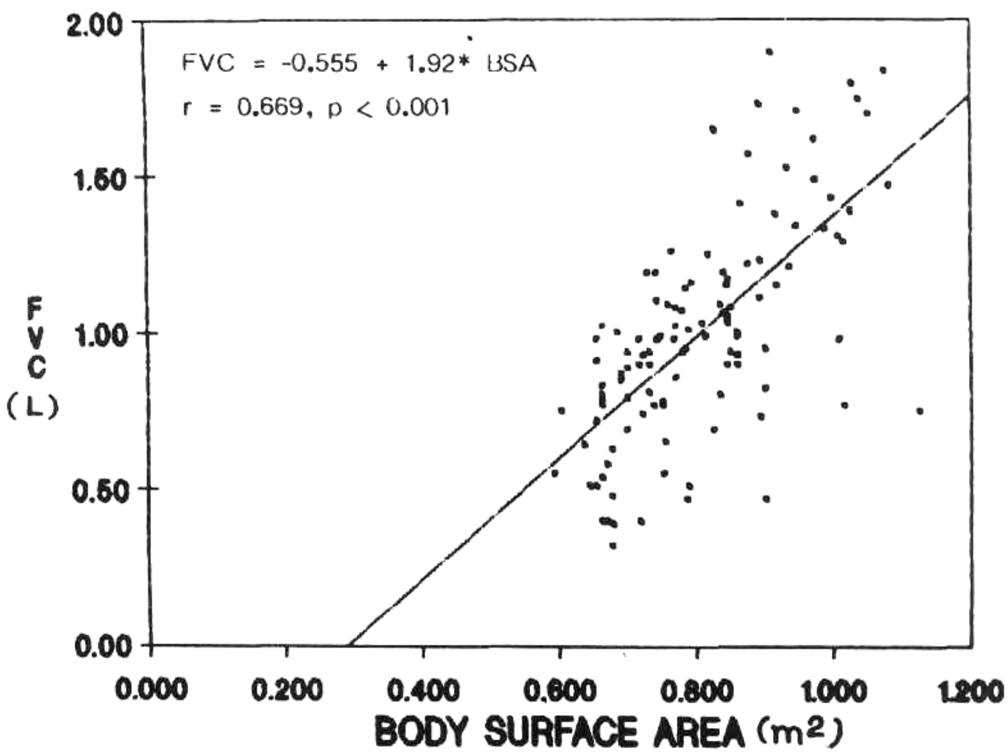

Fig. 3. Scatterogram showing Forced Vital Capacity (FVC) in relation to body surface area (BSA).

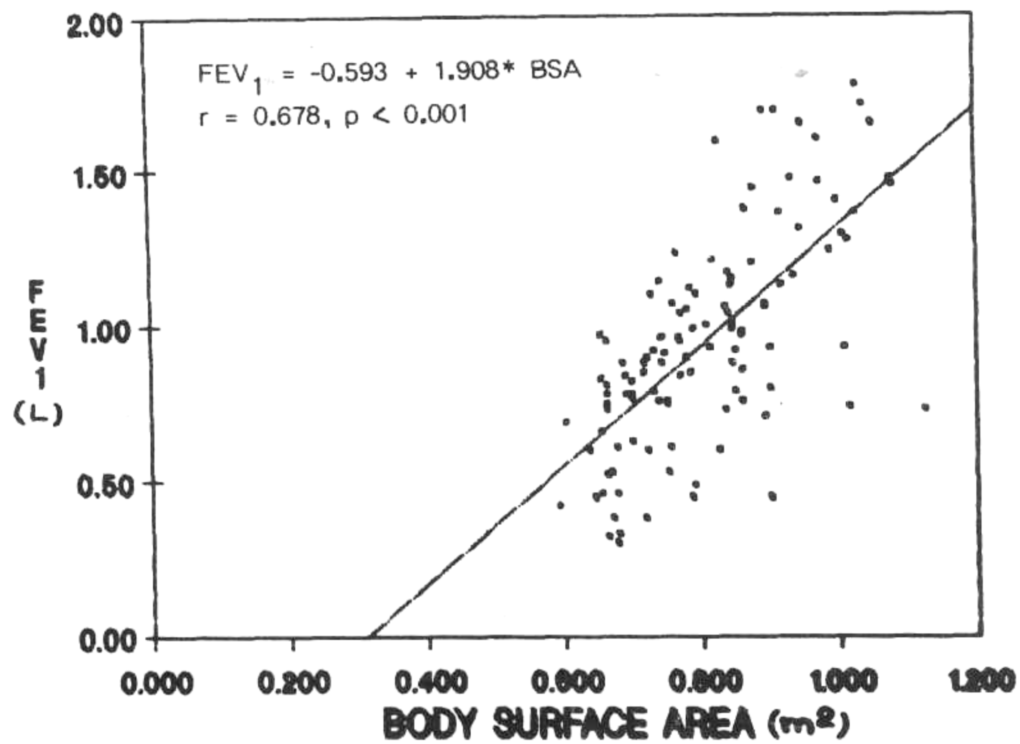

Fig. 4. Scatterogram showing one second Forced Expiratory Volume (FEV_1) in relation to body surface area (BSA).

is available showing the effect of reduction in body surface area and weight on FVC, FEV_1, PEFR, $\%FEV_1$/FVC and Empey Index. Bhattacharya and Bannerjee(11), and others(12-15) calculated FVC in healthy children which was in general agreement with our observations in healthy children. Only Singh and Prabhakaran(15) reported higher values of FVC than our children. Similarly, FEV_1 in our healthy children was comparable to values reported by Deshpande *et al.* (13) and others(14,16). $\%FEV_1$/FVC was calculated by few workers(12,13) which was comparable to our values. However, Singh and Prabhakaran(15) reported lower $\%FEV_1$/FVC than our healthy children. On the other hand there was wide variation in PEFR as reported by various workers(12-14, 17-19). Except Jain and Ramiah(12) whose values were lower than ours and Singh and Peri(19) who had comparable data for 5-7 years, all other workers(13,14,17,18) reported higher PEFR values than our children. This difference may be attributed to technical reasons as small children do not cooperate properly. None of the workers had calculated Empey Index(6) in children

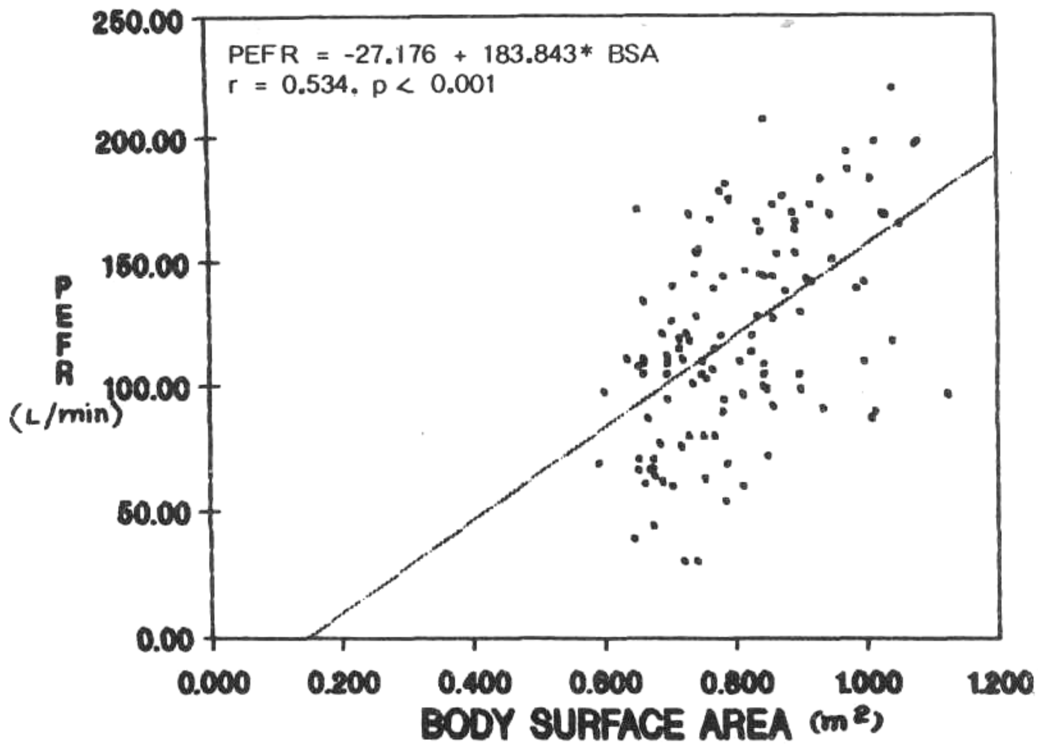

Fig. 5. Scatterogram showing Peak Expiratory Flow Rate (PEFR) in relation to body surface area (BSA).

so far and, therefore, it was difficult to compare our observations.

In general our observations on respiratory functions in healthy children are in conformity with majority of workers(11-19). The age matched corresponding values of respiratory functions are reduced in malnourished subjects which signified that PEM adversely affected respiratory functions in children. Hence, there is a need to carry further research in this area.

These findings have great clinico-therapeutic implications. Reduction in respiratory parameters need not be pathognomonic of some respiratory illness but may be the effect of PEM which is so common in all the developing nations including India. One should be cautious in interpreting the abnormal respiratory functions in malnourished children.

Acknowledgements

We are thankful to UCMS Computer Centre, for providing facilities of computation and literature search on MEDLINE.

The paper was presented in the XXXVIII Annual Conference of the "Association of Physiologists and Pharmacologists of India" (APPI) during December, 1992 at New Delhi, and was awarded the "Harish Gupta Prize".

REFERENCES

1. Ninth Report of the joint FAO/WHO Expert Committee on Nutrition. Food and Nutrition Strategies in National Development. WHO Tech Rep Ser No, 584, 1976, pp 8-10.
2. 'Basic Principles for Control of Acute Respiratory Infections in Children in Developing Countries—A Joint WHO/ UNICEF Statement, Geneva, WHO, 1986.
3. Keele CA, Neil E, Joels N. Respiration. *In:* Samson Wright's Applied Physiology, 13th edn. Oxford, Oxford University Press,. 1982, pp 158-217.
4. Shah PM. Report of Nutrition Sub committee of the Indian Academy of Pediatrics. Indian Pediatr 1972, 9: 360.
5. Vaughan VC, Litt IF. Growth and development. *In:* Nelson Textbook of Pediatrics, 14th edn. Eds Berhman RE, Kliegman RM, Nelson WE, Vaughan VC. Philadelphia, WB Saunders Co, 1987, pp 13-104.
6. Empey DW. Assessment of upper airways obstruction. Br Med J 1972, 3: 503-505.
7. Faridi MMA, Ansari Z, Tyagi SP. Skele tal muscle changes in protein energy malnutrition. J Trop Pediatr 1988, 34: 238-243.
8. Krishnamurthy DI, Karen S, Krishnamurthy D, Chandra H. Skeletal muscle changes in Kwashiorkor: A clinicopathologic study. Indian Pediatr 1971, 8: 814-821.
9. Montogomery RD. Muscle morphology in infantile protein malnutrition. J Clin Pathol 1962, 50: 511-521.
10. Apps MCP. A guide to lung function tests. J Appl Med 1993, 19: 31-36.
11. Bhattacharya AK, Bannerjee S. Vital capacity in children and young adults of India. Indian J Med Res 1966, 54: 62-71.
12. Jain SK, Ramiah TJ. Lung volumes and mechanics of breathing in healthy boys, 7-14 years old. Indian J Chest Dis 1968, 10: 63-68.
13. Deshpande JN, Dahat HB, Shirole CD, Pande AH. Pulmonary functions and their correlation with anthropometric parameters in rural children. Indian J Pediatr 1983, 50: 375-378.
14. Pande AH, Pande SH. Dynamic pulmonary functions in children and their correlation with their armspan. Indian J Pediatr 1984, 51: 541-543.
15. Singh HD, Prabhakaran S. Pulmonary function studies: A preliminary note. J Indian Med Assoc 1957, 29: 269-272.
16. Pande AH, Deshpande JN. Prediction of timed vital capacity from height and weight in children in the age group of 5 to 12 years. Indian J Pediatr 1984, 51: 537-539.
17. Parmar VR, Kumar L, Malik SK. Normal values of Peak expiratory flow rate in healthy North Indian school children, 6-16 years of age. Indian Pediatr 1977, 14: 591-594.
18. Pande AH. Prediction of peak expiratory flow rate from height and weight. Indian J Pediatr 1986, 53: 521-523.
19. Singh HD, Peri S. Peak expiratory flow rates in South Indian children and adolescents. Indian Pediatr 1978,15: 473-478.