

Original Research Article

Pulmonary function in overweight and obese children aged 6-12 years: a hospital and school-based observational study

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ABSTRACT

Background: Childhood overweight and obesity may adversely influence respiratory mechanics and pulmonary function through mechanical restriction of the chest wall, altered diaphragmatic excursion, and changes in lung volumes. This study aimed to assess pulmonary function among overweight and obese children aged 6 to 12 years and compare spirometric parameters between BMI categories.

Methods: A hospital-and school-based observational study was conducted among 45 overweight and obese children aged 6 to 12 years at Government Medical College and Hospital, Cuddalore District, Tamil Nadu, and selected schools in the district from December 2024 to May 2026. Baseline demographic and anthropometric characteristics were recorded. Pulmonary function was assessed using spirometry, including peak expiratory flow rate (PEFR), forced expiratory volume in the first second (FEV₁), forced vital capacity (FVC), and FEV₁/FVC ratio. Observed values were compared with normal predicted values derived using Chhabra equations, and pulmonary function parameters were compared between overweight and obese children. Data were analysed using SPSS version 26.0.

Results: The mean age was 10.31±0.90 years, and the mean BMI was 22.13±3.08 kg/m². Of the 45 participants, 21 (46.7%) were overweight and 24 (53.3%) were obese. The mean PEFR, FEV₁, and FVC were 3.74±0.96 L/s, 1.37±0.36 L, and 1.36±0.37 L, respectively. Their corresponding mean percentage predicted values were 69.82±21.62, 53.71±13.06, and 48.43±12.55. The mean FEV₁/FVC percentage predicted remained preserved at 107.52±2.56. Obese children showed slightly higher absolute spirometric values than overweight children.

Conclusions: Overweight and obese children demonstrated reduced PEFR, FEV₁, and FVC compared with predicted normal values, while the FEV₁/FVC ratio remained preserved. Early pulmonary assessment and appropriate weight-management interventions may help reduce long-term respiratory consequences.

Keywords: Childhood obesity, Overweight, Pulmonary function, Spirometry, FEV₁

INTRODUCTION

Childhood overweight and obesity have become one of the defining child-health problems of this century. A pooled global analysis of population-representative data showed that obesity among school-aged children and adolescents continued to rise between 1990 and 2022, with some of the steepest increases in low- and middle-income countries.¹ India reflects this transition, and a systematic review of Indian studies estimated that nearly

one in five children was overweight or obese, with higher figures in urban and affluent groups.² Changes in diet, shrinking opportunities for outdoor play, longer screen time and rapid urbanisation have brought this problem beyond metropolitan cities, so that overweight children are now regularly encountered in district-level hospitals and schools as well.

The metabolic and cardiovascular consequences of childhood obesity are widely recognised, but its effect on

the respiratory system receives comparatively little attention in routine paediatric care. Fat deposited over the chest wall and within the abdomen reduces chest-wall compliance, pushes the diaphragm upward and lowers end-expiratory lung volume, so that the child breathes at lower lung volumes and with a greater work of breathing.³ Obesity is also accompanied by low-grade systemic inflammation, which may further alter airway behaviour independent of these mechanical effects.^{4,5}

The effect of obesity on lung function in children is not simply a smaller version of what is seen in adults, because the paediatric lung and airways are still growing. A meta-analysis found that in adults obesity was associated with lower FEV₁ and FVC, whereas in children it was more often associated with normal or even higher FEV₁ and FVC but a lower FEV₁/FVC ratio.⁶ This has been explained by dysanapsis, in which lung volume grows in proportion to body size while airway calibre fails to keep pace.⁷ Other studies, however, have reported reduced FEV₁ and FVC with a preserved ratio, suggesting a restrictive rather than an obstructive pattern.⁸⁻¹⁰ The direction and size of change therefore appear to depend on age, the degree and distribution of adiposity, and the reference standard used to define normality.¹¹⁻¹³

Spirometry is a simple, non-invasive and reproducible test that most children can perform reliably from about six years of age when international standards for acceptability and repeatability are followed.¹⁴ Because lung function in children varies with height, age, sex and ethnicity, observed values must be interpreted against population-appropriate reference equations.^{15,16} The Chhabra equations were developed in healthy Indian children aged 6-17 years using current standardisation protocols and provide an Indian reference for this age group.¹⁷ Region-specific values have also been described for south Indian children, and the choice of reference equation can substantially change the proportion of children labelled as having reduced lung function.¹⁵

Most Indian studies on obesity and lung function have involved adolescents, have been confined to either a school or a hospital population, or have used older regional reference values.^{9,18-20} Data on primary-school-aged children from Tamil Nadu, particularly from district-level settings, remain limited. Combining a teaching hospital with schools allows inclusion of children who seek medical care as well as apparently healthy children in the community, in whom excess weight is often not perceived as a health problem by the family. Demonstrating a measurable reduction in lung function in such children can give the clinician an objective and easily understood finding with which to support counselling on weight control and physical activity.

The present study was therefore undertaken to assess PEFR, FEV₁, FVC and the FEV₁/FVC ratio among overweight and obese children aged 6 to 12 years recruited from a government medical college hospital and

schools in Cuddalore District, Tamil Nadu, to compare the observed values with predicted values derived from the Chhabra equations, and to compare spirometric parameters between overweight and obese children.

Aim

Aim was to assess pulmonary function among overweight and obese children aged 6 to 12 years and to evaluate variations in spirometric parameters in relation to body mass index category.

Objectives

Objectives were to assess pulmonary function parameters, including PEFR, FEV₁, FVC, and the FEV₁/FVC ratio, and to compare the observed values with normal predicted values derived using Chhabra equations and to compare pulmonary function parameters between overweight and obese children and evaluate differences in PEFR, FEV₁, FVC, and FEV₁/FVC percentage predicted values between the two BMI categories.

METHODS

Study design, setting and period

This was a hospital- and school-based observational (cross-sectional) study conducted in the Department of Paediatrics, Government Medical College and Hospital, Cuddalore District, Tamil Nadu, India. The study was carried out over a period of December 2024 to may 2026.

Ethical considerations

The study protocol was approved by the Institutional Ethics Committee of Government Medical College and Hospital, Cuddalore District (01.08.2025) Permission was obtained from the heads of the participating schools. Written informed consent was obtained from a parent or legal guardian of every child, and verbal assent was obtained from the child before enrolment.

Study population and sample

Children aged 6 to 12 years attending the paediatric outpatient department of Government Medical College and Hospital, Cuddalore District, and children studying in the selected schools, were screened by measurement of height and weight. Children classified as overweight or obese according to the operational definitions given below, and fulfilling the eligibility criteria, were enrolled. A total of 45 children were included in the study.

Inclusion and exclusion criteria

Children aged 6 to 12 years who were identified as overweight or obese at Government Medical College and Hospital, Cuddalore District, or in the selected schools,

and whose parents or legal guardians provided written informed consent were included in the study.

Children aged less than 6 years or more than 12 years were excluded. Children with diagnosed asthma or other chronic respiratory disorders, and those with a history of low birth weight or premature birth, were also excluded to minimise the influence of pre-existing factors known to affect pulmonary function.

Operational definitions

Overweight

Children with BMI between the 85th and 95th percentile for age and sex were classified as overweight.

Obesity

Children with BMI above the 95th percentile for age and sex were classified as obese.

PEFR

Peak expiratory flow rate was defined as the maximum flow achieved during a forceful expiration following maximal inspiration and was expressed in litres per second.

FEV₁

FEV₁ was defined as the volume of air forcefully exhaled during the first second of a forced expiratory maneuver following maximal inspiration.

FVC

FVC was defined as the total volume of air forcefully exhaled after maximal inspiration.

FEV₁/FVC ratio

The FEV₁/FVC ratio represented the proportion of the FVC exhaled during the first second of forced expiration.

Percentage predicted value

The percentage predicted value represented the observed pulmonary function value expressed as a percentage of the corresponding normal predicted value derived using reference equations.

Anthropometric assessment

Weight was measured to the nearest 0.1 kg using a calibrated digital weighing scale with the child in light clothing and without footwear. Height was measured to the nearest 0.1 cm using a stadiometer with the child standing barefoot. Body mass index was calculated as

weight in kilograms divided by the square of height in metres and plotted on IAP age- and sex-specific BMI charts.

Spirometry

Spirometry was performed using a computerised spirometer (safety) in accordance with the American Thoracic Society/European Respiratory Society recommendations.¹⁴ The procedure was explained and demonstrated to each child before testing, and the test was performed in the sitting position with a nose clip in place. Each child performed at least three acceptable forced expiratory manoeuvres, and the best values of PEFR, FEV₁ and FVC (pre-best values) were recorded. Predicted values were calculated using the Chhabra equations based on the child's age, height and sex.¹⁷ Observed values were then expressed as a percentage of the predicted values.

Statistical analysis

Data were entered in Microsoft Excel and analysed using IBM SPSS Statistics version 26.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean±SD and categorical variables as frequency and percentage. Spirometric parameters were compared between overweight and obese children using the independent samples t test. A p value of less than 0.05 was considered statistically significant.

RESULTS

Table 1 summarizes the baseline characteristics of the study participants. The mean age of the children was 10.31±0.90 years. Male participants constituted 64.4% of the sample, while females accounted for 35.6%. The mean weight, height, and body mass index were 46.73±8.67 kg, 144.73±6.28 cm, and 22.13±3.08 kg/m², respectively. Of the 45 children included in the study, 21 (46.7%) were overweight and 24 (53.3%) were obese.

Table 2 presents the overall pulmonary function parameters among overweight and obese children. The mean pre-best PEFR was 3.74±0.96 L/s, with a mean PEFR percentage predicted of 69.82±21.62. The mean pre-best FEV₁ was 1.37±0.36 L, while the corresponding percentage predicted value was 53.71±13.06. The mean pre-best FVC was 1.36±0.37 L, with a mean FVC percentage predicted of 48.43±12.55. The mean FEV₁/FVC percentage predicted was 107.52±2.56. Overall, PEFR, FEV₁, and FVC percentage predicted values were reduced, whereas the FEV₁/FVC ratio remained relatively preserved.

Table 3 compares pulmonary function parameters between overweight and obese children. Obese children demonstrated slightly higher absolute PEFR, FEV₁, and FVC values than overweight children. The mean PEFR percentage predicted was 72.53±22.09 in obese children

compared with 66.72 ± 21.18 in overweight children, while the mean FEV₁ percentage predicted was 55.41 ± 13.97 and 51.75 ± 11.97 , respectively. The mean FVC percentage predicted was nearly similar in the two groups, measuring 48.61 ± 13.20 among obese children and 48.22 ± 12.07 among overweight children. The FEV₁/FVC percentage predicted remained relatively preserved in both groups.

Table 1: Baseline characteristics of the study participants.

Variables	Value
Age (in years), Mean $\pm$ SD	10.31 $\pm$ 0.90
Male, N (%)	29 (64.4)
Female, N (%)	16 (35.6)
Weight (kg), Mean $\pm$ SD	46.73 $\pm$ 8.67
Height (cm), Mean $\pm$ SD	144.73 $\pm$ 6.28
BMI (kg/m ²), Mean $\pm$ SD	22.13 $\pm$ 3.08
Overweight, N (%)	21 (46.7)
Obese, N (%)	24 (53.3)

Table 2: Overall pulmonary function parameters among overweight and obese children.

Pulmonary function parameter	Mean $\pm$ SD
PEFR pre best (l/s)	3.74 $\pm$ 0.96
PEFR % predicted	69.82 $\pm$ 21.62
FEV ₁ pre best (l)	1.37 $\pm$ 0.36
FEV ₁ % predicted	53.71 $\pm$ 13.06
FVC pre best (l)	1.36 $\pm$ 0.37
FVC % predicted	48.43 $\pm$ 12.55
FEV ₁ /FVC % predicted	107.52 $\pm$ 2.56

Table 3: Comparison of pulmonary function parameters between overweight and obese children.

Pulmonary function parameters	Overweight, mean $\pm$ SD	Obese, mean $\pm$ SD
PEFR pre best (l/s)	3.53 $\pm$ 1.04	3.93 $\pm$ 0.87
PEFR % predicted	66.72 $\pm$ 21.18	72.53 $\pm$ 22.09
FEV ₁ pre best (l)	1.28 $\pm$ 0.29	1.44 $\pm$ 0.40
FEV ₁ % predicted	51.75 $\pm$ 11.97	55.41 $\pm$ 13.97
FVC pre best (l)	1.30 $\pm$ 0.33	1.42 $\pm$ 0.40
FVC % predicted	48.22 $\pm$ 12.07	48.61 $\pm$ 13.20
FEV ₁ /FVC % predicted	106.90 $\pm$ 3.29	108.06 $\pm$ 1.56

DISCUSSION

The present study evaluated pulmonary function among 45 overweight and obese children aged 6 to 12 years, of whom 21 (46.7%) were overweight and 24 (53.3%) were obese. The mean age of the participants was 10.31 ± 0.90 years, with a mean BMI of 22.13 ± 3.08 kg/m². These findings are comparable with those of Satapathy et al who evaluated pulmonary function among children aged 6-14 years across different BMI categories and observed that excess body weight was associated with measurable

variations in spirometric parameters.⁹ Raji et al in contrast, found no statistically significant difference in most spirometric parameters between obese and non-obese schoolchildren, underlining the inconsistency of findings across studies.¹⁸ Paralikar et al and Shingne et al reported alterations in respiratory function among obese adolescents, supporting the need for early pulmonary assessment in children with elevated BMI.^{19,20}

The overall pulmonary function profile in the present study showed a mean PEFR of 3.74 ± 0.96 L/s, mean FEV₁ of 1.37 ± 0.36 L, and mean FVC of 1.36 ± 0.37 L. The corresponding mean percentage predicted values were 69.82 ± 21.62 for PEFR, 53.71 ± 13.06 for FEV₁, and 48.43 ± 12.55 for FVC. In contrast, the mean FEV₁/FVC percentage predicted remained relatively preserved at 107.52 ± 2.56 . This pattern indicates reduced expiratory flow and lung volumes with preservation of the FEV₁/FVC ratio. Spathopoulos et al reported lower FVC and FEV₁ values among overweight and obese school-aged children.⁸ Satapathy et al also observed reductions in percentage predicted FEV₁ and FVC with increasing BMI.⁹ Shingne et al documented decreased FVC and FEV₁ among obese adolescents, and Paralikar et al reported adverse effects of obesity on ventilatory parameters.^{19,20} The findings of the present study therefore support previous evidence that excess body weight may impair pulmonary mechanics, particularly by reducing lung volumes.

Age-wise comparison with normal predicted values derived using Chhabra equations showed that observed PEFR, FEV₁, and FVC were generally lower than expected across the different age groups. The reduction was especially evident for FEV₁ and FVC, whereas the FEV₁/FVC ratio remained preserved and exceeded 100% of predicted values. The lowest mean PEFR percentage predicted was noted among 10-year-old children, whereas FVC percentage predicted remained reduced across all age groups. These observations are consistent with Vijayan et al who emphasized that pulmonary function in children varies considerably with age, height, and other anthropometric factors and should be interpreted using age-appropriate reference values.¹⁵ Budhiraja et al similarly highlighted the importance of population-specific pediatric pulmonary reference standards.¹⁶ Spathopoulos et al and Ferreira et al also demonstrated lower pulmonary function indices among children with obesity, further supporting the present findings.^{8,21}

Comparison between overweight and obese children showed that obese children had slightly higher absolute values of PEFR, FEV₁, and FVC than overweight children. The mean PEFR percentage predicted was 72.53 ± 22.09 in obese children compared with 66.72 ± 21.18 in overweight children, while the mean FEV₁ percentage predicted was 55.41 ± 13.97 and 51.75 ± 11.97 , respectively. The mean FVC percentage predicted was nearly identical in the two groups, measuring 48.61 ± 13.20 among obese children and

48.22±12.07 among overweight children. The FEV₁/FVC percentage predicted remained preserved in both categories.

This finding illustrates the complexity of interpreting pulmonary function according to obesity severity, as higher absolute values may partly reflect larger body size rather than better respiratory function. The meta-analysis by Forno et al likewise showed that children with obesity often have normal or higher absolute FEV₁ and FVC than their normal-weight peers.⁶ Raji et al found that sex had a greater influence than obesity status on spirometric values among adolescents.¹⁸ Rao et al demonstrated that central adiposity may independently influence spirometric measures.¹¹ Das et al observed that some overweight children may have higher absolute lung volumes because of greater body dimensions.²² Torun et al showed that the degree of obesity can differentially affect pulmonary function.¹⁰

The relatively preserved FEV₁/FVC ratio observed in the present study suggests that the predominant functional abnormality may be related to reduced lung volumes rather than overt airflow obstruction. Excess adiposity can mechanically restrict chest wall expansion, reduce diaphragmatic excursion, and increase the work of breathing, thereby lowering FVC and FEV₁ while maintaining the ratio between them. Salome et al described the mechanical consequences of obesity on respiratory physiology.³ Dixon and Peters highlighted that obesity can alter lung volumes and airway function through both mechanical and inflammatory pathways.⁴ Kongkiattikul et al likewise demonstrated associations between obesity indices and impaired pulmonary function among obese children and adolescents.¹²

Overall, the present study reinforces the importance of assessing pulmonary function in children with elevated BMI. Reduced PEFR, FEV₁, and FVC may represent early subclinical respiratory impairment even in the absence of known chronic respiratory disease. Similar concerns have been raised by Charoensittisup et al who showed that increasing adiposity over time may adversely affect pulmonary function.²³ Yao et al demonstrated that obesity can disproportionately influence lung volumes and airflow in children.¹³ Early identification of such abnormalities may provide an opportunity for timely lifestyle modification, weight management, and periodic respiratory follow-up.

Limitations

The study was limited by its small sample size and recruitment from selected hospital and school settings, which may restrict the generalizability of the findings. In addition, the observational design did not allow assessment of longitudinal changes in pulmonary function following weight reduction or lifestyle modification.

CONCLUSION

The present study demonstrated that overweight and obese children aged 6 to 12 years had reduced pulmonary function parameters, particularly PEFR, FEV₁, and FVC, when compared with predicted normal values, while the FEV₁/FVC ratio remained relatively preserved. Although obese children showed slightly higher absolute spirometric values than overweight children, the percentage predicted values remained reduced in both groups, suggesting that excess body weight may adversely affect pulmonary mechanics and lung volumes during childhood.

Early pulmonary function assessment should be considered in overweight and obese children, particularly those at risk of progressive weight gain. Lifestyle interventions focusing on healthy dietary practices, regular physical activity, weight control, and periodic follow-up of respiratory function are recommended to identify early functional impairment and potentially reduce long-term respiratory consequences.

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Conflict of interest: None declared

Ethical approval: The study was approved by the Institutional Ethics Committee

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