Effect of body mass index (BMI) on pulmonary functions in children of 6-14 years of age: A cross-sectional study

Amit K. Satapathy¹, Rashmi R. Das¹, Samarendra Mahapatro¹, Manoj K. Panigrahi², Debapriya Bandopadhaya³

Departments of ¹Pediatrics, ²Pulmonary Medicine, and ³Biochemistry, AIIMS, Bhubaneswar, Odisha, India

ABSTRACT

Background: Over-weight/obesity is a new global pandemic affecting children with prevalence up to 36%. It is responsible for metabolic syndrome and its future complications in children; however, its effect on lung functions in children is not well studied. Aim: To compare lung function tests [forced expiratory volume in the first second (FEV1), FEV1/forced vital capacity (FVC), FVC, and % predicted] of children with over-weight/obesity to that of normal children. Method: It is a hospital-based cross-sectional study. Children of 6-14 years of age with over-weight [body mass index (BMI) >85th centile] and obesity (BMI >95th centile) attending the pediatrics outpatient department (OPD) were included. Age-matched children attending the OPD during the study period were selected as controls. Demographic and anthropometric details were collected, and pulmonary function tests were carried out in included children. Results: A total of 103 children were included (over-weight/obese = 56, control = 47). The percent predicted (%) FEV1 (86.23 ± 12.84 vs 91.77 ± 8.68) and FVC (81.93 ± 12.12 vs 88.62 ± 10.87) were significantly lower in the obese/over-weight group as compared to control group. A significant negative correlation was found between FEV1 (%) and FVC (%) and that of BMI and waist-hip ratio (WHR). Conclusions: Pulmonary functions (FEV1, FVC) are found to be negatively correlated with BMI and WHR.

Keywords: BMI, body mass index, children, obesity, PFT, pulmonary function test

Introduction

Over-weight/obesity has become a global pandemic affecting children of all age groups. In the United States (USA), approximately 60% of adults and 25% of children and adolescents can be classified as over-weight/obese. Although more studies are needed to ascertain the prevalence of over-weight/obesity in India, the prevalence varies from 7.4% to 36% in different studies. Childhood obesity has both short- and long-term health concerns including metabolic syndrome, cardiovascular disease, and type 2 diabetes mellitus during the adolescent period and adulthood.

Address for correspondence: Dr. Amit Kumar Satapathy, Department of Pediatrics, AIIMS, Bhubaneswar, Odisha - 751019, India. E-mail: amitkumar.satapathy@yahoo.co.in

Received: 07-10-2021  Revised: 16-01-2022  Accepted: 22-01-2022  Published: 30-06-2022

Access this article online

Quick Response Code:

Website: www.jfmpc.com

DOI: 10.4103/jfmpc.jfmpc_2002_21

How to cite this article: Satapathy AK, Das RR, Mahapatro S, Panigrahi MK, Bandopadhaya D. Effect of Body Mass Index (BMI) on pulmonary function in children of 6-14 years age: A cross-sectional study. J Family Med Prim Care 2022;11:3156-60.
Materials and Methods

Children of 6–14 years of age presenting to the pediatric outpatient department (OPD) of a tertiary care teaching hospital of Eastern India with a body mass index (BMI) of >85th centile were included over a 1-year period (March 2017 to 2018). Those with uncontrolled asthma, heart disease, neuromuscular disease, chest deformity, intellectual disability, and acute respiratory symptoms at presentation were excluded. Details of demographic data were collected after taking proper consent from the parents (and assent wherever applicable). A complete physical examination was performed.

Anthropometric parameters (weight, height, waist, and hip circumference) were measured with light clothing without shoes: weight to the nearest 100 g, height (using a stadiometer) to the nearest centimeter (cm), waist circumference (cm) at the mid-point between the costal margin and iliac crest in the mid-axillary line, and hip circumference (cm) at the prominence of buttocks. Blood pressure (BP) was measured with a standardized digital instrument in the right arm in the sitting position three times (0-, 5-, and 30-minute intervals), and the average was taken. BMI was calculated (kg/m²) as per the standard formula and classified into controls. The mean (± SD) weight of the control group was 32.4 (± 6.64) kg, and that of the obese/over-weight group was 56.5 (± 12.8) kg. The mean height (± SD) of the control and obese/over-weight group was 139 (± 9) cm and 142 (± 12) cm, respectively. The BMI of the obese/over-weight group was 26.62 (± 3.78) kg/m², whereas that of the control group was 16.55 (± 1.75) kg/m². The waist-hip ratio (WHR) in the obese/over-weight group was 0.96, whereas in the control group, it was 0.90 [Table 1].

Pulmonary function test was carried out in all the included children. The mean (± SD) FVC in the obese/over-weight group was 1.91 L (± 0.48), whereas that of the normal group was 2.01 L (± 0.48). Although children with obesity/over-weight have a lower FVC as compared to the control group, it was not statistically significant. Similarly, the mean (± SD) FEV1 in the control group (1.85 L ± 0.42) was higher than the obese/over-weight group (1.76 L ± 0.44) but was not again statistically significant. However, the percentage (%) predicted FEV1 and FVC were significantly different between the two groups [Table 2].

We also tried to find out correlation between pulmonary functions (FVC, FEV1, and FEV1/FVC) and various factors such as height, weight, BMI, and WHR. The results are presented.
in Table 3. We found a negative correlation between FVC and FEV1 with BMI and WHR but a positive correlation between weight and height. None of these correlations were statistically significant. However, we found a significant negative correlation between percent (%) predicted FEV1 and FVC with that of BMI and WHR.

**Discussion**

In the present study, the percent predicted (%) FEV1 (86.23±12.84 vs 91.77±8.68) and FVC (81.93±12.12 vs 88.62±10.87) were significantly lower in the obese/over-weight group as compared to the control group. A significant negative correlation was also found between FEV1 (%) and FVC (%) and that of BMI and WHR.

Children with over-weight and obesity may have variables which differ from that of children with normal BMI including metabolic parameters and lung functions. Obesity causing reduction of reserve volume and FVC is well established in adult studies. However, the results in children are conflicting.

| Parameters | Obesity (n=56) | Control (n=47) |
|------------|---------------|---------------|
| FEV1 (%)   | 86.23±12.84   | 91.77±8.68    |
| FVC (%)    | 81.93±12.12   | 88.62±10.87   |
| FEV1/FVC   | 92.65±2.8     | 93.32±7.99    |
| FEV1/FVC (%)| 105.93±8.32  | 105.51±9.03   |

In the present study, we did not find any statistically significant difference in FEV1 among obese/over-weight children versus that of children in the control group. Similarly, we could not document any difference between FVC and FEV1/FVC unlike some of the previously published studies showing statistically significant lower FEV1 and FVC among children with obesity. Nageswari et al. reported lower FEV1 and FVC in obese children as compared to controls of age 12–16 years, although the sample size was 20 in each group. However, Cibella et al. reported a similar result in a cross-sectional study. However, we found a significant difference between FEV1 (%) and FVC (%) among children with obesity and those in the control group. Both FEV1 and FVC were lower in children with obesity compared to controls, which was similar to a previously published cross-sectional study by Ulger et al. done in children with obesity between 9 and 15 years of age. Another study found similar results to the present study, where there was no significant difference in FEV1, FVC, or FEV1/FVC, but significant reductions were noted in PEF and FEV1/FVC 25–75 in the over-weight, obese, and morbidly obese children as compared to normal children.

**Table 2: Pulmonary function between the obese/over-weight and control groups**

| Parameters | Obesity | Normal | P |
|------------|---------|--------|---|
| FEV1 (L)   | 1.76±0.44 | 1.85±0.42 | 0.30 |
| FEV1 (%)   | 86.23±12.84 | 91.77±8.68 | 0.01* |
| FVC (%)    | 81.93±12.12 | 88.62±10.87 | 0.004* |
| FEV1/FVC   | 92.65±2.8 | 93.32±7.99 | 0.84 |
| FEV1/FVC (%)| 105.93±8.32 | 105.51±9.03 | 0.80 |

\( p \leq 0.05 \)
We also looked at correlation between pulmonary functions and various factors such as BMI, weight, height, and WHR. There was a significant negative correlation between the FEV1 (%) and FVC (%) with that of BMI and WHR in contrast to a previously published study, which noted a positive correlation between BMI and pulmonary function test. Our results are in accordance with studies where BMI and WHR are negatively correlated to pulmonary function test. Yet another study had reported a significant (or almost significant) inverse correlation with residual FVC, FEV1, and FEV1/VC among boys with over-weight and obesity. BMI also showed inverse correlations with residual FVC and FEV1, both of which were border-line significant. WHR was concluded as the best predictor of residual FVC, FEV1, and FEV1 in the over-weight or obese group in the same study.

The strength of the present study is that children with over-weight/obesity were age-matched prospectively with the control group, thus preventing any bias arising from a retrospective design. However, the limitation includes a small sample size and a higher number of boys in the obesity/over-weight group as compared to girls.

Conclusions

Pulmonary functions (FEV1, FVC) decline with an increase in BMI and WHR, although not significantly. FEV1 (%) and FVC (%) decrease significantly with an increase in BMI. Although BMI and WHR have a negative correlation with pulmonary functions, they are statistically insignificant. Height and weight have a positive correlation with pulmonary functions, which is significant.

Summary

- Pulmonary functions (FEV1, FVC) decline with an increase in BMI and WHR.
- FEV1 (%) and FVC (%) decrease significantly with an increase in BMI.
- BMI and WHR have a negative correlation with PFT, but they are statistically insignificant.
- Height and weight have a positive correlation with pulmonary functions, which is significant.
- We have used healthy controls for comparing PFT, which have not been used previously in most of the studies.

Take home message

- BMI and WHR adversely affect the pulmonary function in children.
- % FEV1 and FVC decrease with an increase in BMI. Hence, the results of pulmonary function test used for evaluation of children with asthma should be carefully interpreted.
- As there is increasing prevalence of both obesity and asthma in children, primary physicians should be aware of these adverse affects of obesity of pulmonary functions.

Financial support and sponsorship

Funded by AIIMS Bhubaneswar Intramural Research Grant.

Conflicts of interest

There are no conflicts of interest.

References

1. Obesity: Preventing and managing the global epidemic. Report of a WHO consultation. World Health Organ Tech Rep Ser 2006;894:1-12, 1-253.
2. Dietz WH. Health consequences of obesity in youth: Childhood predictors of adult disease. Pediatrics 1998;101:518-25.
3. Das RR, Mangaraj M, Panigrahi SK, Satapathy AK, Mahapatro S, Ray PS. Metabolic syndrome and insulin resistance in schoolchildren from a developing country. Front Nutr 2020;7:31.
4. Kapil U, Singh P, Pathak P, Dwivedi N, Bhasin S. Prevalence of obesity amongst affluent schoolchildren in Delhi. Indian Pediatr 2002;39:449-52.
5. Chandra N, Anne B, Venkatesh K, Teja GD, Katkam SK. Prevalence of childhood obesity in an affluent school in Telangana using the recent IAP growth chart: A pilot study. Indian J Endocr Metab 2019;23:428-32.
6. Lang JE, Bunnell HT, Hossain MJ, Wysocki T, Lima JJ, Finkel TH, et al. Being overweight or obese and the development of asthma. Pediatrics 2018;142:e20182119.
7. Parameswaran K, Todd DC, Soth M. Altered respiratory physiology in obesity. Can Respir J 2006;13:203-10.
8. Ceylan E, Comlekci A, Akkoklu A, Ceylan C, Itıl O, Ergor G, et al. The effects of body fat distribution on pulmonary function tests in the overweight and obese. South Med J 2009;102:30-5.
9. Li A, Chan D, Wong E, Yin J, Nelson E, Fok T. The effects of obesity on pulmonary function. Arch Dis Child 2003;88:361-3.
10. Ho TF, Tay JS, Yip WC, Rajan U. Evaluation of lung function in Singapore obese children. J Singapore Paediatr Soc 1989;31:46-52.
11. Ferreira MS, Marson FAL, Wolf VLV, Ribeiro JD, Mendes RT. Lung function in obese children and adolescents without respiratory disease: A systematic review. BMC Pulm Med 2020;20:281.
12. Khaddilkar VV, Khadilkar AV, Borade AB, Chiplonkar SA. Body mass index cut-offs for screening for childhood overweight and obesity in Indian children. Indian Pediatr 2012;49:29-34.
13. Graham BL, Steenbruggen I, Miller MR, Barjaktarevic IZ, Cooper BG, Hall GL, et al. Standardization of spirometry 2019 update. An Official American Thoracic Society and European Respiratory Society Technical Statement. Am J Respir Crit Care Med 2019;200:e70-88.
14. Huang L, Ye Z, Lu J, Kong C, Zhu Q, Huang B, et al. Effects of fat distribution on lung function in young adults. J Physiol Anthropol 2019;38:7.
15. Del Rio-Camacho G, Domínguez-Garrido MN, Pita J, Aragón I, Collado R, Soriao-Guillén L. Left ventricular mass, forced baseline spirometry and adipokine profiles in obese children with and without metabolic syndrome. An Pediatr (Barc) 2013;78:27-34.
16. Torun E, Cakir E, Ožgücü F, Ozgen İ. The effect of obesity
degree on childhood pulmonary function tests. Balkan Med J 2014;31:235-8.
17. Bekkers MB, Wijga AH, de Jongste JC, Kerkhof M, Postma D, Gehring U, et al. Waist circumference, BMI, and lung function in 8-year-old children: The PIAMA birth cohort study. Pediatr Pulmonol 2013;48:674-82.
18. Muñoz Cofré R, Del Sol M, Medina González P, Escobar Inostroza J, Lizana PA, Conei D, et al. Relation among body mass index, waist-hip ratio, and pulmonary functional residual capacity in normal weight versus obese Chilean children: A cross-sectional study. Arch Argent Pediatr 2019;117:230-6.
19. Yao TC, Tsai HJ, Chang SW, Chung RH, Hsu JY, Tsai MH, et al. Obesity disproportionately impacts lung volumes, airflow and exhaled nitric oxide in children. PLoS One 2017;12:e0174691.
20. Paralíkar SJ, Kathrotia RG, Pathak NR, Jani MB. Assessment of pulmonary functions in obese adolescent boys. Lung India 2012;29:236-40.
21. Nageswari KS, Sharma R, Kohli DR. Assessment of respiratory and sympathetic cardiovascular parameters in obese school children. Indian J Physiol Pharmacol 2007;51:235-43.
22. Cibella F, Cuttitta G, La Grutta S, Melis MR, Bucchieri S, Viegi G. A cross-sectional study assessing the relationship between BMI, asthma, atopy, and eNO among schoolchildren. Ann Allergy Asthma Immunol 2011;107:330-6.
23. Ulger Z, Demir E, Tanaç R, Göksen D, Gülen F, Darcan S, et al. The effect of childhood obesity on respiratory function tests and airway hyperresponsiveness. Turk J Pediatr 2006;48:43-50.
24. Yao TC, Tsai HJ, Chang SW, Chung RH, Hsu JY, Tsai MH, et al. Obesity disproportionately impacts lung volumes, airflow and exhaled nitric oxide in children. PLoS One 2017;12:e0174691.
25. Pathopoulos D, Paraskakis E, Trypsianis G, Tsalkidis A, Arvanitidou V, Emporiadou M, et al. The effect of obesity on pulmonary lung function of school aged children in Greece. Pediatr Pulmonol 2009;44:273-80.